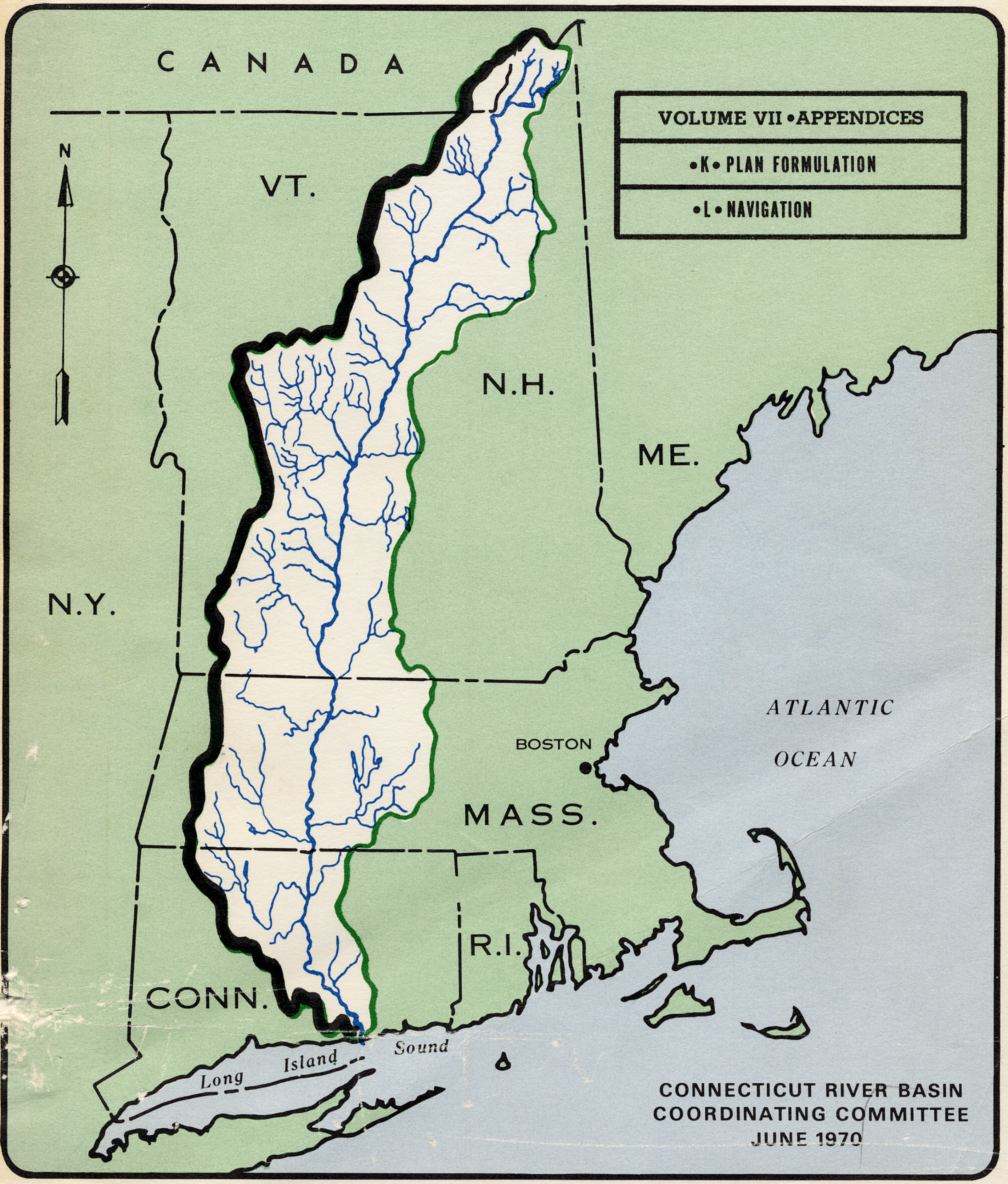
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION

CONNECTICUT RIVER BASIN



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CONNECTICUT RIVER BASIN
COORDINATING COMMITTEE
JUNE 1970

COMPREHENSIVE WATER AND RELATED LAND RESOURCES
CONNECTICUT RIVER BASIN

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COMPREHENSIVE WATER AND RELATED LAND RESOURCES

CONNECTICUT RIVER BASIN

APPENDIX K

PLAN FORMULATION

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NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

JUNE 1970

APPENDIX K

PLAN FORMULATION

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I INTRODUCTION

A. PURPOSE AND SCOPE

1. Study Objectives

The general objective of the Coordinating Committee is the formulation of a basin plan that will serve as a flexible guide for the orderly development and optimum utilization of the water and related land resources of the basin. The basin plan places emphasis on those actions found necessary to meet water resources needs for the 1980 time frame, and referenced as the Early Action Plan, and identifies potential measures to meet needs through the year 2020.

The Connecticut River Comprehensive Study is one of a series of water resource planning studies being performed for the entire nation under the overall guidance and direction of the Water Resources Council. The basin plan, to be used as a guide in development of the basin's natural water and related land resources, has given consideration to meeting present and future requirements for water supply, flood control, navigation, hydroelectric power, recreation, fish and wildlife, and other purposes which depend on or are related to water resources. These are commonly referred to as multiple purposes or uses. Generally, multiple-purpose development affords a way to optimize resources of water and land, to maximize benefits, and to conserve natural resources.

Current guidelines in comprehensive water and related land resource plan formulation provide for consideration of multiple objectives as well as multiple water resource uses. These multiple objectives have been identified as National Efficiency, Regional Development and Environmental Quality and are discussed in detail in Section VI of this appendix.

In addition to the three plan formulation objectives, the following policies, principles, and assumptions formed the basis for preparation of this report:

a. The plan made maximum use of all available data and previous studies.

b. The plan considered all beneficial uses of the land and water resources of the basin area.

c. The recommended plan makes maximum use of those authorities, responsibilities, and going programs of existing Federal, State, and local agencies.

d. The plan is intended to be a flexible document capable of being modified and updated periodically to meet changing conditions in future years. In many instances, the plan is conceptual as much as it is applicable. This means that the end is sometimes more important than the measure that is ultimately employed to meet that end.

2. Areal Extent

The basin's study area consists of that portion of the Connecticut River Basin which is within the United States. It contains 11,136 square miles and extends 280 miles from Canada to Long Island Sound. It includes land in four States, of which 13% is in Connecticut, 24% in Massachusetts, 28% in New Hampshire, and 35% in Vermont. Excluded from this study are 114 square miles in Canada. The main river separates New Hampshire and Vermont along its west bank and cuts through the west central sections of Massachusetts and Connecticut. From a hydrological standpoint, the Connecticut River drains 41% of Vermont, 33% of Massachusetts and New Hampshire, and 29% of Connecticut.

To facilitate study of such a large river basin, the study area was delineated into six sub-basins. These referenced subdivisions were to provide control at the basin level, at the State level, and at a sub-state level to permit greater detail in areas where desirable.

It is recognized that no one areal breakdown of the basin, whether based on economic, physical, social, biological, or political factors would be completely satisfactory for all purposes. However, the six-part subdivision, as shown on Plate K-1, proved to be a suitable tool for use in this study. Further areal subdivisions of the basin as required for special study purposes, for example, sub-basin or tributary analyses, were coordinated within this framework.

The process of identifying present and future resource development needs consisted of examining the demand for resources or the extent of resource problems; then examining the capabilities of existing resource developments to meet these demands or solve these problems. The study dealt with demands on the basin's resources originating from within the basin and from outside; however, at the same time, the study was limited to within the basin in its consideration of resource capabilities. Because of this, a basis for separating the "in" from the "out" for both demands and resources capabilities was essential.

The large size and diversity in area of the basin made it an unwieldy unit for planning. The basin is not homogenous in terms of physical, economic, or other factors. To obtain a reasonable degree of harmony in the planning framework for patterns of economic activities, political distinctions, physical characteristics, and the availability of useful data, areal compromises were made.

The resources of the basin were inventoried within a basin framework for State portions, generally by counties. Major items of population and economic activity were projected for sub-state areas which approximated the basin. The closest connection between the two was at the county or "groups of counties" level. The inventory data which was already on a basin basis was adjusted as required, to fit a scheme of delineation below the basin level. Projective data, although it closely approximated the basin, required some adjustment to fit the basin area.

The State area provided a natural four-section framework for sub-basin delineation. The part of the basin in New Hampshire and Vermont which represents about 2/3 of the total area of the basin, is sufficiently different from south to north so that a split in the area north of White River Junction, Vermont and Hanover, New Hampshire was made. This resulted in the six sub-basins shown on Plate K-1.

From a hydrologic standpoint, the Upper Basin was considered to include all of the area that drained into the Connecticut River including, and upstream of its confluence with the Omponpanoosuc River. The Middle Basin includes all the watershed south of the Upper Basin which drains into the main stem of the Connecticut River at the northern Massachusetts State line. The Lower Basin includes that remaining portion of the basin which is south of the Middle Basin. The Upper Basin was further divided into Sub-basin Area I (upper New Hampshire) and Sub-basin Area II (upper Vermont). The Middle Basin was divided into Sub-basin Area III (lower New Hampshire) and Sub-basin Area IV (lower Vermont). The Lower Basin was divided into Sub-basin Area V (Massachusetts) and Sub-basin VI (Connecticut). Area V was considered as that part of the watershed upstream of the confluence of the Westfield River with the main stem of the Connecticut River.

B. ASSUMPTIONS, METHODOLOGY, AND DEFINITIONS

Maximum utilization was made of existing data such as the report of New England-New York Inter-Agency Committee (NENYIAC) and reports of Federal, State and private agencies. Development of new data was minimized and screening of alternative measures was accomplished to the maximum extent practicable by use of past studies and records, reconnaissance, and consultation among personnel of participating agencies.

The investigation:

a. identified the general nature and scope of water and related land resources development needs which will be encountered in future years, confining planning studies to meet the minimum detail and scope necessary to meet these requirements;

b. defined and evaluated in sufficient detail to comprise a basis for authorization studies of those projects for which Federal authorization will be required to permit necessary construction to be initiated by 1980;

c. identified the nature and scope of the additional elements of the plan which should be undertaken under non-Federal or other Federal programs by 1980;

d. and identified potentials for meeting the needs through 2020 including increased scale warranted at projects required by 1980.

Individual study elements were considered only to the point necessary to arrive at the conclusions required at the particular stage of the study. Studies of features and elements were terminated when it was determined that the particular feature or element was not justified for inclusion as part of the comprehensive plan. During later individual authorization reports, further refinements in project scope and detail may be accomplished.

The investigations included active participation and cooperation by Federal agencies and appropriate regional, State, and local public agencies and interests. The views of each were considered and taken into account in the determination of requirements and in the formulation of plans for resource use and development.

Future needs were estimated for 1980, 2000, and 2020. Projective economic studies provided the forecast dimension of demographic and economic factors and served as tools for estimating requirements for water and related land uses. In addition to the Arthur D. Little studies, later projections developed by the Office of Business Economics, Department of Commerce, the Economic Research Service, and the Forest Service of the Department of Agriculture were used for over-all guidance.

Consideration was given to the need for additional water diversion into or out of the basin.

The formulation of plans and evaluation of improvements conform to policies, standards, and procedures set forth in Senate Document No. 97, 87th Congress, 2nd Session, entitled: "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources" and amendments approved jointly by the Secretaries of Agriculture, Army, Interior, and Health, Education, and Welfare.

The report presents an allocation, on a functional basis of the costs of recommended projects together with appropriate recommendations, for Federal and non-Federal cost sharing.

The report suggests ways and means to implement the comprehensive plan recommended for initial development and to phase the construction of the elements of the plan.

Projects in which there are primary or substantial Federal interests and which are urgently needed were covered by interim reports. The essentials of such interim reports are part of the final report.

To the extent necessary for plan implementation, the report presents basic principles which should be covered in water resource laws.

Public hearings were held as required at the onset of the study to receive information on water resource needs and during later phases of the study to present basin development plans and to receive views relative thereto.

Progress reports were prepared by the Corps of Engineers in accordance with existing regulations. In addition, periodic reports of status were made to the Coordinating Committee and interested public and private groups were apprised as to status of the investigations.

1. Assumptions

The comprehensive plan is predicated on a series of assumptions which include:

a. that the nation will continue to enjoy a period of relative stability with no major wars or depressions; and

b. that water will be available in sufficient quantity and of adequate quality so that projections and growth will not be adversely affected.

These assumptions were used as guides in the development and utilization of demographic and economic projections.

2. Economic Criteria

In the formulation of the basin plan a number of economic guidelines were adhered to. Consideration was given to all purposes which could be served by water and related land resource development. Each component of the plan was evaluated, in the final analysis, on the contribution it would make to the net benefits of the total basin plan, rather than to any single purpose. Also, to the extent possible, all tangible and intangible benefits and costs were incorporated into the evaluation process. Finally, it should be recognized that many of the elements of the recommended plan will undergo more refined cost and benefit analysis in later design stages prior to project construction.

The planning process reviewed both present needs and problems and those anticipated in the future. The recommended Early Action Plan attempts to recommend measures required to meet 1980 needs and problems in a manner which will also provide the best base for expansion to meet future requirements. The economic projection period for the study terminated with the 2020 target year, with the 1980 used as the short-range benchmark. In instances where the useful life of a project extended to longer periods, adjustments were required in the cost and benefit analysis. For example, in the analysis of reservoir projects which have a productive life of well over 50 years, a reasonable extrapolation was made of available projective economic data.

Price levels prevailing on or about June 1969 were used as an index in evaluating costs and benefits for most study features. However, cost estimates of upstream watershed reservoirs were developed using 1965 price levels. An interest rate of 4-7/8% was used in analyzing Federal investment, as directed by the Water Resources Council. Future costs and benefits were discounted to present worth using the Federal rate of 4-7/8%.

The period of analysis used in the evaluation of projects was the useful life of the project. In general, the evaluation period varied from 20 or 25 years for waste treatment facilities, to 100 years for major reservoir projects. In the development of future benefits attributable to Early Action projects, preference was given to satisfaction of 2020 needs at these projects rather than at projects which are identified as potentials for construction after 1980.

C. COORDINATION

As regional representative of the Chief of Engineers, the Division Engineer of the New England Division, U.S. Army Corps of Engineers was assigned the major responsibility for the accomplishment of the study. Assistance in guidance was afforded by the Coordinating Committee which is comprised of representatives of each of the participating Federal agencies and a representative designated by the Governor of each State within the basin. The Division Engineer, as Chairman, directed the Committee's periodic review of the progress of the study. The Committee's function included the following:

a. offer guidance,

b. apprise the heads of the Federal agencies and the States of the trends of the study,

c. resolve differences,

d. coordination of efforts of participants, and

e. aid in presenting to the public, the results of coordinated comprehensive planning effort.

II PLANNING ENVIRONMENT

A. AUTHORITY

The Connecticut River Basin Comprehensive Study is one of the original sixteen Type II river basin studies selected by the Interdepartmental Staff Committee of the Ad Hoc Water Resource Council for completion by 1970. Authority for participation and for preparation of the comprehensive report on the Connecticut Basin is contained in resolution of the Committee on Public Works of the United States Senate adopted 11 May 1962.

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved 12 June 1902, be and is hereby, requested to review the reports of the Connecticut River, Massachusetts, New Hampshire, Vermont, and Connecticut, published as House Document Numbered 455, Seventy-fifth Congress, second session and other reports, with a view to determining the advisability of modifying the existing project at the present time, with particular reference to developing a comprehensive plan of improvement for the basin in the interest of flood control, navigation, hydroelectric power development, water supply and other purposes, coordinated with related land resources."

B. GUIDING DOCUMENTS

On January 30, 1961 the report of the Senate Select Committee on National Water Resources was made public. The report recognized the expanding needs for water and related land resources and called for the Federal Government in cooperation with the States to prepare and keep up to date plans for comprehensive development and management for all major river basins of the United States. In order to accomplish this goal in an efficient manner, the President on October 6, 1961 asked the Secretaries of Agriculture; Army, Interior; and Health, Education, and Welfare to recommend, for his approval, policies, standards and procedures for formulation and evaluation of water resources use and development. As a result of this undertaking, the four Federal agencies submitted a joint statement to the President on May 15, 1962 entitled: "Policies, Standards, and Procedures in the Formulation Evaluation, and Review of Plans for Use and Development of Water and Related Land

Resources". It was adopted on May 29, 1962 as Senate Document No. 97 by the 87th Congress, 2nd Session.

Senate Document No. 97 set the following as objectives of planning:

- The basic objective in the formulation of plans is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs. ***

- National economic development and development of each region within the country is essential to the maintenance of national strength and the achievement of satisfactory levels of living. Water and related land resources development and management are essential to economic development and growth. ***

- Well-being of all of the people shall be the overriding determinant in considering the best use of water and related land resources. Hardship and basic needs of particular groups within the general public shall be of concern, but care shall be taken to avoid resource use and development for the benefit of a few or the disadvantage of many. In particular, policy requirements and guides established by the Congress and aimed at assuring that the use of natural resources, including water resources, safeguard the interests of all of our people shall be observed. ***

The Connecticut River Basin Comprehensive Study since its authorization by Senate Resolution in May 1962 has used the broad objectives of S 97 as a basis for plan formulation.

On July 22, 1965 Congress passed the Water Resources Planning Act (PL 89-80, 89th Congress) which provides for "the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources, through the establishment of a water resources council and river basin commissions, and by providing financial assistance to the States in order to increase State participation in such planning".

The Coordinating Committee for the Study has since acted with the guidance of the Water Resources Council, which was formed under *Title I of the Water Resources Act. Title II of the same act authorized* the establishment of river basin commissions and resulted in the later formation of the New England River Basins Commission. This latter commission delegated a representative to serve as a member of the Connecticut Study Coordinating Committee in June of 1968. Since that time, the Commission has been an active participant in the basin study.

C. STUDY CONTROLS

1. Water Resources Council

The Water Resources Council was established by the Water Resources Planning Act (Public Law 89-80) which was approved July 23, 1965. The function of the Council is to encourage the conservation, development, and use of the water and related land resources of the United States. This is to be done on a comprehensive and coordinated basis by the Federal Government, States, localities, and the private sector, all operating in concert. Members of the Council are the Secretary of the Interior (Chairman), the Secretary of Agriculture, the Secretary of the Army, the Secretary of Health, Education, and Welfare, the Secretary of Transportation, and the Chairman of the Federal Power Commission. The Secretary of Commerce and the Secretary of Housing and Urban Development are Associate Members and the Director of the Bureau of the Budget serves as an official observer.

2. Connecticut River Basin Coordinating Committee

The Committee is made up of representatives of the Department of Agriculture; the Army (the Chair agency); Commerce; Health, Education, and Welfare; the Interior; the Federal Power Commission; the Governors of Connecticut, Massachusetts, New Hampshire, and Vermont; and the New England River Basins Commission. The Coordination Committee has guided and participated actively in the investigation that led to the development of the Connecticut River Basin Comprehensive Plan. This plan is intended to serve as a guide to the best use, or combination of uses, of water and related land resources of the basin to meet foreseeable short- and long-term requirements.

3. New England River Basins Commission

The New England River Basins Commission was established by the President of the United States in 1967 at the request of the Governors of the New England States and the State of New York. The Commission has been created to serve as a focal point for the development of comprehensive and coordinated joint planning and action. The Commission is a partnership of Federal, State, interstate, and regional agencies. Its Chairman is appointed by the President, and its Vice-chairman is selected by the New England States.

The Study Coordinating Committee has recommended the establishment of a special Connecticut River Basin Program within the New England River Basins Commission to provide leadership and coordination in carrying out the water and related land resources management programs proposed by the study using existing Federal, State, interstate, and local authorities, agencies, and programs as implementing media.

4. Agency Participation

Federal agencies participated in varying degrees under the guidance of the Coordinating Committee during the course of the Study. Several agencies of the four basin States assisted in the investigations by providing available data from State studies as well as advice to the participating Federal agencies.

a. Executive Sessions of the Coordinating Committee were held periodically during the course of the study. These sessions were conducted by the Chairman, so as to allow full discussions, exchange of ideas, and exploration of differences. Executive meetings were opened to staff and/or consultants at the request of the members or alternates of the Coordinating Committee.

b. Staff Level Meetings were informal sessions between various study participants of the State and Federal agencies. These meetings provided a means by which the separate agency programs could be presented, reviewed, and modified for each area of the basin.

c. Between December 1966 and July 1968 nine Round Table Plan Formulation Meetings were held on the various areas of the basin. The meetings were attended by technical level personnel who evaluated the needs and problems of the basin and weighed possible solutions to resolve them. The following is a list with dates of the meetings by sub-areas of the basin:

Round Table No.	CRB Area		Date
1	I	Upper New Hampshire	December 14, 1966
2	II	Upper Vermont	February 28, 1967
3	III IV	Lower New Hampshire Lower Vermont	June 5, 1967
4	V	Massachusetts	September 8, 1967
5	VI	Connecticut	November 21, 1967
6	I II	Upper New Hampshire Upper Vermont	January 31, 1968
7	III IV	Lower New Hampshire Lower Vermont	April 9, 1968
8	V	Massachusetts	May 27, 1968
9	VI	Connecticut	July 16, 1968

The final round of plan formulation meetings started on 20 October 1969 through a session called a "Think Tank". The participating State and Federal agencies were asked to send a representative with authority to make decisions regarding the formulation of the final Connecticut River Basin plan. The "Think Tank" lasted for a period of two weeks and resulted in the formulation of the final basin plan. The results of the plan were documented subsequent to the "Think Tank" and were presented to the general public in an Information Packet early in January 1970.

d. Interim Reports - Throughout the course of investigation, numerous study reports were prepared and presented to participants. A listing of these reports is contained in Appendix A of this report. Status reports were prepared at six-month intervals and presented to the public at the Public Sessions of the Coordinating Committee held each fall and spring. A listing of the Public Sessions with agenda of each session is also included in Appendix A.

5. Public Participation

Starting early in the study, every attempt was made to gage the desires of the general public. Four formal Public Hearings were held during the spring and fall of 1964. Ten Public Sessions of the Coordinating Committee were held throughout the basin during the course of the study at intervals of approximately six months. Prepared minutes were distributed to those who attended these meetings. In addition, study participants held numerous informal meetings and correspondence was exchanged with interested smaller groups and individual citizens.

During the last year of the study, ten Regional Public Information meetings were held in key interest areas of the basin. Information gathered throughout these interchanges with the public was considered and taken into account by the Coordinating Committee during the final plan formulation session. In some instances, the Committee was not able to meet local desires and, as planners, were obligated to choose that plan which in their opinion best met the needs of all the people on an overall basis.

The basin plan was documented in summary form in an Information Packet that was distributed to the public prior to final Public Hearings. This Information Packet was disseminated to the public to provide information and sufficient time to review the extensive proposals and findings.

The four final Public Hearings were held to give the citizens of the basin an opportunity to express their views freely, fully, and publicly with regard to the Coordinating Committee's selected plan. Digests of these Public Hearings were made a part of the final report. The report of the Subcommittee on Public Information, which is included in Appendix Q, presents a summary of presentations at the Public Hearings as well as a discussion of the effectiveness of public participation in this comprehensive study.

III PRESENT ENVIRONMENT

A. BASIN WATER RESOURCES

Ample water resources for all uses within the basin result from an average annual precipitation of 43 inches. This precipitation falls on, and is regulated by, a land cover which is dominated by forest. The runoff from this precipitation is therefore relatively well regulated, and of outstanding quality in many upstream reaches where pollution from human activity has not become a dominant factor.

1. Natural Water Resources

The Connecticut River main stem follows a general southerly course along the approximate center line of its watershed for about 404 miles to its mouth on Long Island Sound at Saybrook, Connecticut. The lower 60-mile reach of the river is tidal having a mean tidal range during low river stages of 3.4 feet at the mouth and about 1.2 feet at Hartford some 52 miles upstream of the mouth.

Wide and extensive flood plains are located at various reaches along the main stem. During major floods, these meadow lands become inundated to varying depths of from 10 to 20 feet, and act as large natural detention reservoirs which significantly reduce peak discharges. The most noteworthy natural areas of storage are as follows: between West Stewartston and Lancaster, New Hampshire; a 15-mile reach between Woodsville, New Hampshire and Bradford, Vermont; in central Massachusetts between Montague City and Holyoke; and also the most extensive flood plains between Windsor Locks and Middletown, Connecticut. The combined natural storage available in these valley areas is greater than all of the existing flood control storage dams.

In its southerly course to the ocean, the Connecticut is fed by numerous rivers and streams entering from east and west. Significant tributaries are contained in Table 1. The fifteen largest tributaries having watershed areas larger than 200 square miles divide an aggregate total of 6,517 square miles, or 58% of the basin area. They are as follows:

Upper Ammonoosuc River
Ammonoosuc River
Mascoma River
Sugar River
West River
Millers River
Chicopee River
Farmington River
Passumpsic River
White River
Ottauquechee River
Black River
Ashuelot River
Deerfield River
Westfield River

Further details on these principal tributaries may be found in Appendix C.

TABLE 1
PERTINENT DATA - CONNECTICUT RIVER TRIBUTARIES

NAME	STATE	DRAINAGE AREA (s.m.)	LENGTH (mi.)	APPROX. FALL (ft.)	MOUTH LOCATION	MOUTH CONN. R. MILEAGE*
Perry Stream	NH	30	13	875	Pittsburg	387
Indian Stream	NH	71	16	280	Pittsburg	377
Halls Stream	Quebec, NH, Vt	89	22	830	Beecher Falls	372
Mohawk River	NH	25	11	850	Colebrook	359
Nulhegan River	Vt	151	16	280	Bloomfield	345
Paul Stream	Vt	58	14	940	Brunswick	340
Upper Ammonoosuc	NH	254	40	1350	Northumberland	325
Israel River	NH	135	21	1450	Lancaster	312
Johns River	NH	76	9	200	Dalton	303
Passumpsic R.	Vt	507	23	250	Barnet	280
Stevens River	Vt	49	7	430	Barnet	277
Ammonoosuc R.	NH	402	56	4550	Woodsville	266
Wells River	Vt	100	16	680	Wells River	266
Waits River	Vt	146	24	1950	Bradford	247
Ompompanoosuc R.	Vt	136	20	800	Norwich	225
White River	Vt	712	58	2175	White R. Jct.	215
Mascoma R.	NH	194	34	1000	Lebanon	214
Ottauquechee R.	Vt	222	38	1475	N. Hartland	210
Sugar R.	NH	275	27	800	Claremont	195
Little Sugar R.	NH	31	7	550	Charlestown	187
Black R.	Vt	204	40	1050	Springfield	183
Williams R.	Vt	118	24	1330	Rockingham	176
Saxtons R.	Vt	78	20	1560	Westminster	173
West River	Vt	423	53	1775	Brattleboro	149
Ashuelot River	NH	421	64	1475	Hinsdale	140
Millers R.	NH & Mass	392	45	900	Montague-Erving	126
Falls River	Vt & Mass	36	12	400	Gill-Greenfield	122
Deerfield R.	Vt & Mass	664	73	2900	Deerfield-Greenfield	119
Manhan R.	Mass	106	18	900	Easthampton	92
Chicopee River	Mass	721	17	260	Chicopee	80
Westfield R.	Mass & Conn	517	57	1775	W. Springfield	75
Scantic River	Mass & Conn	114	35	900	S. Windsor	59
Farmington R.	Mass & Conn	609	47	350	Windsor	57
Park River	Conn	78	2.2	15	Hartford	51
Hockanum R.	Conn	82	22	510	E. Hartford	50
Mattabesset R.	Conn	105		180	Middletown	33
Salmon R.	Conn	152	20	520	Haddam-E. Haddam	18
Eight Mile River	Conn	61	9	400	Lyme	9

*Above Saybrook Breakwater Light, 0.5 miles below Lynde Point

(a) Reservoirs-Lakes-Ponds

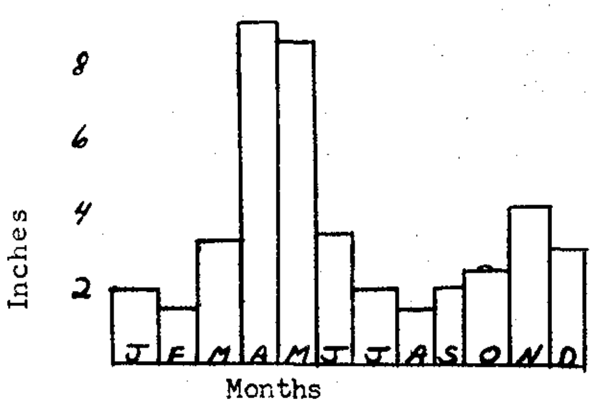
The Connecticut River Basin has many natural and man-made bodies of water. There are 172 bodies of water which range in size from 100 to 499 acres. Of this amount, 29 are used for water supply purposes and 143 are used for other purposes. There are several problems associated with the productivity of these surface water bodies. Apart from the problems related to both the quantity and quality of the recreational activities that occur on or near these water bodies, is the problem of access. For example, of the 172 bodies of water noted, only 61 have public access for recreational use for a broad range of outdoor recreation activities.

The basin has more than 35 bodies larger than 500 acres in size, of which 27 are for non-water supply purposes and 8 for water supply purposes. Public access is provided in 21 of the 35 bodies of water noted. Generally speaking, the management of New England's water supply reservoirs restricts recreation use. However, there are varying degrees of recreational usage at certain water supplies, generally in the upper part of the basin, whereas recreational use is extremely limited in those water supply systems located in the Lower Basin. Past experience inthe use of water supply reservoirs for intensive recreational use is related in detail in Appendix R of this report.

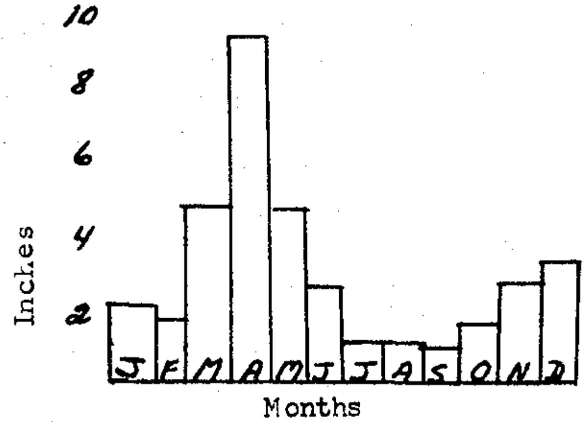
(b) Precipitation

The average annual precipitation over the entire basin is about 43" of water and ranges from 36" to 60". Runoff, that portion of precipitation left after evaporation and transpiration as well as deep underground flow to the sea, averages about one-half or approximately 23". This average is based on a study of New England rainfall, accomplished by the U. S. Weather Bureau. In general, the headwater areas of all major tributaries, except those entering from the east below Bellows Falls, experience precipitation averaging in excess of 60" annually. Most of this precipitation in the higher elevations is in the form of snow and occurs during the winter periods. The range between maximum and minimum values of average monthly precipitation is approximately 1" to 2". Precipitation is generally plentiful throughout the year. Most of it occurs as rain in the southern limits with snow making up the larger percentages in the higher and northern portions. Serious floods have occasionally occurred and the droughts have had pronounced effect upon water quality. (Reference to Figure 1.)

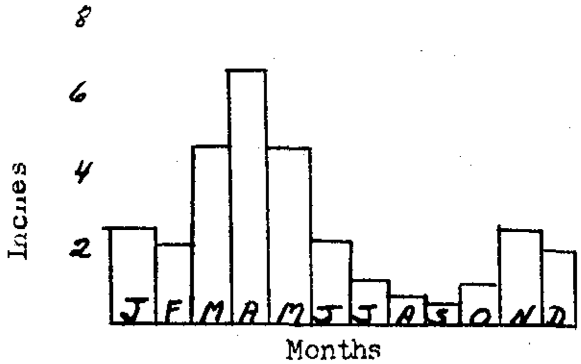
Average Annual Monthly Runoff in Inches for Selected Gages



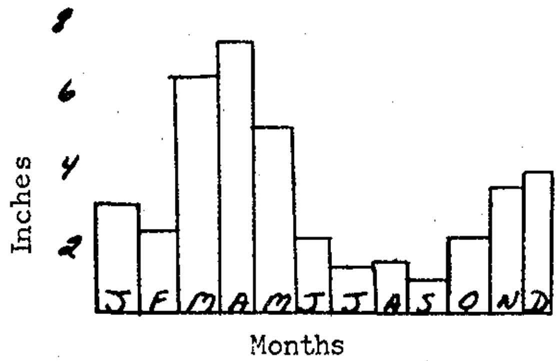
Bethlehem Junction, N.H., on Ammonoosuc River



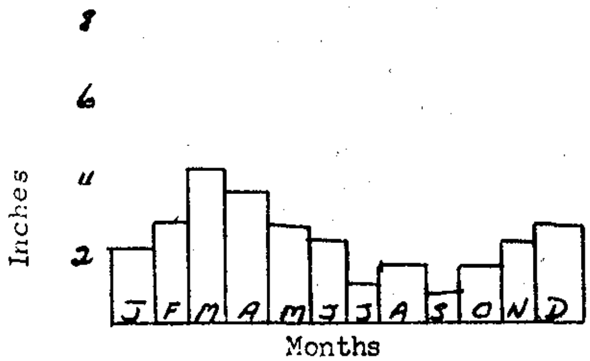
Ottauquechee River at North Hartland, Vermont



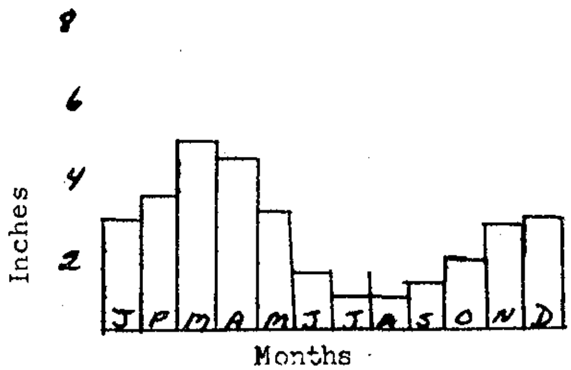
South Branch, Ashuelot River at Webb, near Marlboro, N.H.



West Branch Westfield River at Huntington, Massachusetts



Scantic River at Broad Brook, Conn.



Salmon River near East Hampton, Mass.

FIGURE 1

(c) Storms and Droughts

Three general types of storms cause precipitation over the basin: continental, coastal, and thunder storms. Continental storms originate over the western or central portion of the United States generally travelling easterly or northeasterly in direction and may be rapidly moving intense cyclones or the stationary frontal type. They are not limited to any season or month but follow one another at more or less regular intervals with varying intensities throughout the year. Tropical hurricanes, the most severe of the coastal storms, originate in the South Atlantic or Western Carribean Sea. They usually move in a general path to the south and east of New England but may be drawn over this area. Hurricanes have occurred during the late summer or fall months with a higher incidence in August and September. Extra-tropical coastal storms generally originate near the Middle Atlantic States and travel northward along the coastline. They frequently occur during the autumn, winter and spring months.

The Connecticut Basin lies within the generally classified humid zone where the average annual precipitation is reasonably well distributed throughout the year. The drought history in the basin before 1900 is rather limited; however, since the establishment of gaging stations, drought conditions (low flow periods) have been observed throughout the basin at various times.

A serious drought occurred in the three-year period between 1930 and 1932 which was used by many communities as design criteria for their water supply purposes. Less severe droughts also occurred in 1941, 1942, and again in 1948 and 1950, but the longest and most severe drought in the history of the region occurred in 1961 to 1966. It had a serious impact upon water resources as reflected in its effect upon water supply, water quality, and upon agriculture. It was during this time that a considerable number of water supply facilities failed since they had been designed to handle repetition of the less severe drought of the 1930's. The accumulated deficiency of runoff throughout the basin during the six-year drought period of record varied from about 25" in the north to almost 50" in the south. These values are equivalent to nearly 1 to 2 years of average annual run-off from the respective areas. Further details on this matter may be found in Appendix C.

2. Existing Development of Basin Water and Related Land Resources

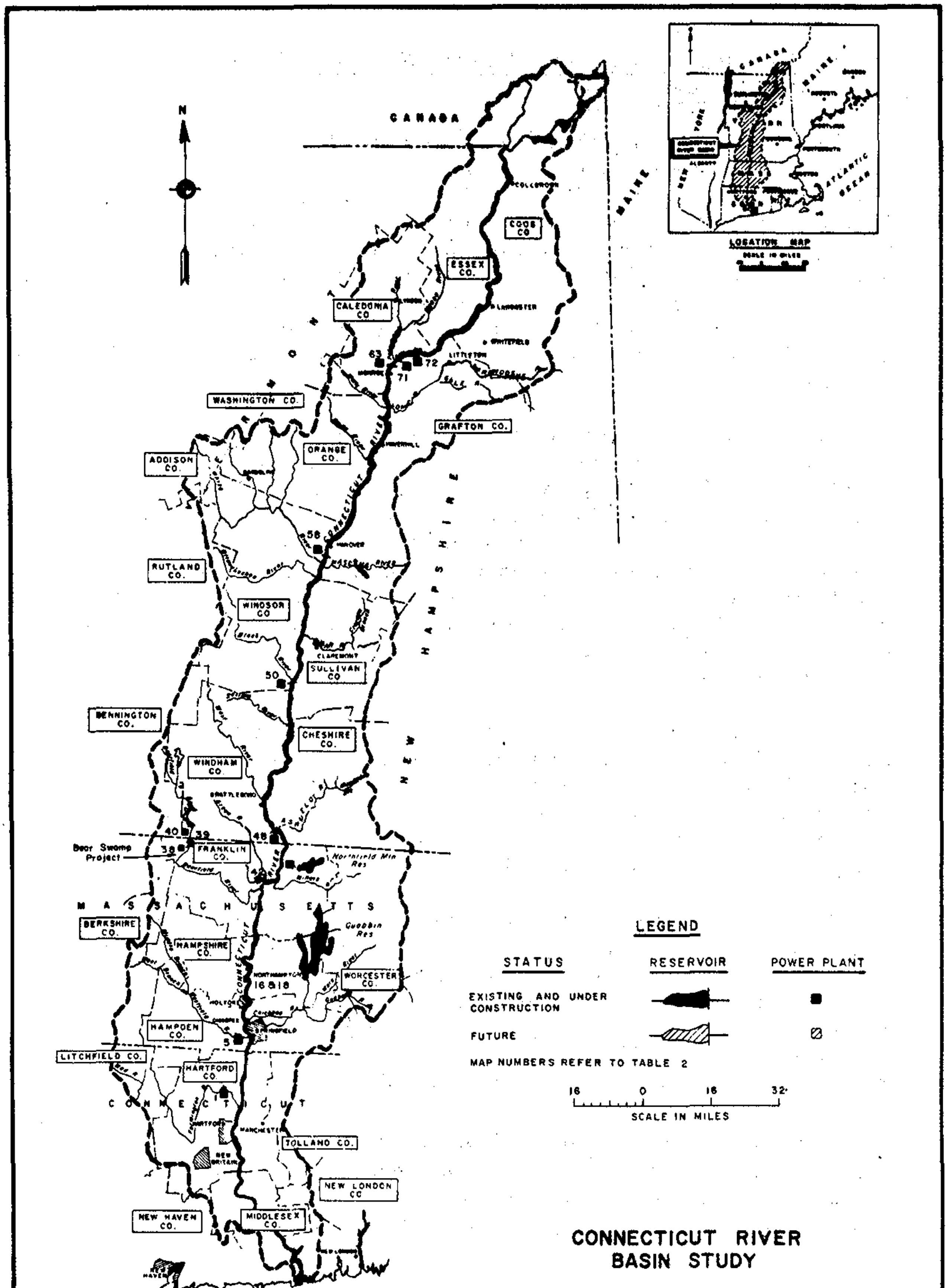
The Connecticut River is one of the nation's hardest working rivers. There are more than 180 dams in the river basin each of which control a minimum of 50 square miles drainage. Storages are utilized for power, water supply, recreation, flood control, and other industrial purposes. At present the resources of the basin are extensively developed for power. This electric power development started very early in the Connecticut River Basin's history, and today 47% of the total conventional hydro potential has been developed, as compared to a 26% average for major streams in the nation.

Most of the hydroelectric developments in the basin have been in existence for some time. Of a total of 75 units shown on Figure 2 and listed in Table 2, some 40 generally under 1,000 kilowatts in size were installed prior to 1920. Of these 75 hydroelectric dams, 47 are operated by utilities and 28 by industrial firms. There are more than 50 power installations of all types in the Connecticut River Basin which have installed capacities greater than 1,000 kw. Most of these plants are hydroelectric, although the combined capacity of the thermal plants is more than three times that of the hydroelectric plants.

At the present time, two nuclear units are in operation - Yankee Atomic (185,000 kw) and Connecticut Yankee (600,000 kw). An additional 550,000 kw of nuclear power is under construction at Vernon, Vermont. Location of the three nuclear plants are shown on Plate K-1 of this appendix, and a more complete inventory of power development in the basin is found in Appendix I.

Under construction in the basin at the present time is the Northfield Mountain pumped storage peaking plant at Northfield, Massachusetts, which is scheduled for completion in late 1971. It will consist of four 250 mw units for a total installed capacity of 1,000 megawatts. The project has a capacity of 1,500 mw. Also under construction is the 600 mw Bear Swamp pumped storage project on the Deerfield River in the State of Massachusetts.

Table 2 lists the existing hydroelectric developments in the basin including 47 utility plants with a generating capacity of about 620 megawatts and 28 industrial projects with an installed capacity of 24 megawatts. The total average annual generation



CONNECTICUT RIVER
BASIN STUDY

BASIN AREA

EXISTING HYDROELECTRIC PROJECTS

FIGURE 2

TABLE 2

Existing Hydroelectric Projects in the Connecticut River Basin

Map No.	Plant Name	River	Owner Class and Owner 1/	Licensed Proj. No.	Drainage Area	Gross Head	Installed Capacity	License Expiration
					Sq. Mi.	Ft.	Kw	
1	Rainbow	Farmington	P Farmington River Pwr. Co.	2577 2/	590	60	8,000	
2	Robertsville	Still	P The Connecticut Light & Pwr. Co.	2688 2/	51	53	500	
3	Windsor Locks	Connecticut	I C. H. Dexter and Sons, Inc.		9,655	27	500	
4	West Springfield	Westfield	I Strathmore Paper Co.	2608	512	32	1,400	12/31/93
5	Cobble Mountain	Westfield	P Western Mass. Elec. Co.		46	456	33,000	
6	Woronoco	Westfield	I Strathmore Paper Co.	2631 2/	348	50	2,690	
7	Russell	Westfield	I Westfield River Paper Co.		341	22	700	
8	Russell	Westfield	I Texon Inc.		326	32	800	
9	Dwight	Chicopee	P Western Mass. Elec. Co.		718	32	1,440	
10	Indian Orchard	Chicopee	P Western Mass. Elec. Co.		687	35	4,900	
11	Ludlow	Chicopee	P Western Mass. Elec. Co.		686	44	3,200	
12	Red Bridge	Chicopee	P Western Mass. Elec. Co.		664	51	3,600	
13	Winsor	Swift	M Metropolitan District Comm.		188	NA	1,200	
14	Ware	Ware	I Ware Industries, Inc.		169	48	1,045	
15	South Barre	Ware	I Barre Wool Combing Co. Ltd.		102	21	150	
16	Hadley Falls	Connecticut	P Holyoke Water Power Co.	2004	8,309	52	15,000	8/31/99
17	Holyoke	Conn. Canal	I Standard Packaging Corp.		8,309	23	1,600	
18	Riverside Station	Conn. Canal	P Holyoke Water Power Co.	2004	8,309	30	7,640	8/31/99
19	Project No. 7	Conn. Canal	I Brown Co.		8,309	20	350	
20	Project Nos. 5 & 6	Conn. Canal	I Brown Co.		8,309	29	720	
21	Project No. 9	Conn. Canal	I Brown Co.		8,309	29	400	
22	Project No. 8	Conn. Canal	I Brown Co.	2497 2/	8,309	29	400	
23	Project Nos. 1 & 2	Conn. Canal	I Brown Co.		8,309	29	720	
24	Project Nos. 3 & 4	Conn. Canal	I Brown Co.		8,309	29	940	
25	Beebee-Holbrook	Conn. Canal	P Holyoke Water Power Co.	2004	8,309	20	516	8/31/99
26	Holyoke	Conn. Canal	I Parsons Paper Co.		8,309	20	486	
27	Project No. 1	Conn. Canal	M Holyoke Gas and Elec. Dept.	2386	8,309	19	1,056	2/28/91
28	Project No. 2	Conn. Canal	M Holyoke Gas and Elec. Dept.	2387	8,309	19	800	3/31/88
29	Project No. 3	Conn. Canal	M Holyoke Gas and Elec. Dept.	2388	8,309	12	450	5/31/90
30	Holyoke	Conn. Canal	I Standard Packaging Corp.		8,309	20	800	
31	Skinner	Conn. Canal	P Holyoke Water Power Co.	2004	8,309	20	300	
32	Boatlock Station	Conn. Canal	P Holyoke Water Power Co.	2004	8,309	20	2,900	8/31/99
33	Easthampton	Manhan	I Easthampton Industrial Prop.		NA	NA	120	
34	Deerfield No. 2	Deerfield	P New England Power Co.	2323	508	65	4,800	12/31/93
35	Gardner Falls	Deerfield	P Western Mass. Elec. Co.	2334	501	39	3,980	12/31/93
36	Deerfield No. 3	Deerfield	P New England Power Co.	2323	500	68	4,800	12/31/93
37	Deerfield No. 4	Deerfield	P New England Power Co.	2323	404	68	4,800	12/31/93
38	Deerfield No. 5	Deerfield	P New England Power Co.	2323	248	245	15,000	12/31/93
39	Sherman	Deerfield	P New England Power Co.	2323	236	80	7,200	12/31/93
40	Harriman	Deerfield	P New England Power Co.	2323	184	390	33,600	12/31/93
41	Searsburg	Deerfield	P New England Power Co.	2323	93	232	4,000	12/31/93
42	Cabot	Conn. Canal	P Western Mass. Elec. Co.	1889	7,138	62	51,000	6/30/70
43	Turners Falls Sta.No.1	Conn. Canal	P Western Mass. Elec. Co.	1889	7,138	48	4,840	6/30/70
44	Turners Falls	Conn. Canal	I Esleeck Manufacturing Co.		7,138	42	450	
45	Turners Falls	Conn. Canal	I Strathmore Paper Co.	2622	7,138	47	937	2/28/91
46	Millers Falls	Millers	I Millers Falls Paper Co.		386	26	1,000	
47	Athol	Millers	I L. S. Starrett Co.		NA	18	112	
48	Vernon	Connecticut	P New England Power Co.	1904	6,266	34	24,400	6/30/70
49	West Dummerston	West	P Cent. Vt. Pub. Service Corp.	2398 2/	345	26	720	
50	Bellows Falls	Connecticut	P New England Power Co.	1855	5,414	62	40,800	6/30/70
51	Springfield	Black	I Fellows Gear Shaper Co.		158	11	449	
52	Cavendish	Black	P Central Vt. Pub.Service Corp.	2489	82	120	1,440	12/31/93
53	West Claremont	Sugar	I Coy Paper Co.		270	33	500	
54	Claremont	Sugar	I Claremont Paper Company, Inc.		270	27	800	
55	Taftsville	Ottauquechee	P Cent. Vt. Pub. Service Corp.	2490	190	17	500	12/31/93
56	Granite State No. 4	Mascoma	P New England Power Co.		195	73	1,300	
57	Bethel	White	I Bethel Mills, Inc.		410	16	193	
58	Wilder	Connecticut	P New England Power Co.	1892	3,375	51	32,400	6/30/70
59	Bradford	Waits	P Cent. Vt. Pub. Service Corp.	2488	160	76	360	12/31/93
60	Woodsville	Ammonoosuc	M Precinct of Woodsville		NA	NA	400	
61	Apthorp	Ammonoosuc	M Littleton Water and Light Dept.		120	19	300	
62	Ryegate	Connecticut	I Ryegate Paper Co.		2,215	13	1,860 3/	
63	McIndoes	Connecticut	P New England Power Co.	2077	2,200	29	10,560	7/31/01
64	West Danville No. 15	Joes Brook	P Green Mountain Power Co.	2540 2/	31	180	1,000	
65	Passumpsic	Passumpsic	P Central Vt. Pub.Service Corp.	2400 2/	424	24	700	
66	Gage	Passumpsic	P Central Vt. Pub.Service Corp.	2397	418	15	700	12/31/93
67	Arnold Falls	Passumpsic	P Central Vt. Pub.Service Corp.	2399	240	17	350	12/31/93
68	Pierce Mills	Passumpsic	P Central Vt. Pub.Service Corp.	2396	227	17	250	12/31/93
69	Great Falls	Passumpsic	M Village of Lyndonville		220	61	600	
70	Vail Station	Passumpsic	M Village of Lyndonville		220	15	350	
71	Comerford	Connecticut	P New England Power Co.	2077	1,635	179	140,400	7/31/01
72	S. C. Moore	Connecticut	P New England Power Co.	2077	1,600	159	140,400	7/31/01
73	Gilman	Connecticut	I Gilman Paper Company	2392	1,514	27	3,390	12/31/90
74	Northumberland	Connecticut	I Groveton Papers Company		1,207	10	750	
75	Canaan	Connecticut	P Public Service Co. of N.H.		381	35	1,100	
				Basin Total			641,814	

1/ P - Privately owned utility; I - Industrial; M - Municipally owned.
2/ Application for license pending.
3/ Kw equivalent of 2500 HP.

amounts to approximately 2.1 billion kilowatt-hours. Projects on the main stem develop over 700 feet of the total fall of 2,100 from headwater to estuary. All plants except Cobble Mountain, Harriman, Moore, and Comerford have pondage sufficient for little more than daily or weekly regulation. When the pumped storage plants currently under construction in the basin are completed, the basin's hydroelectric capacity will have approximately quadrupled over the 1970 figure.

Within the Connecticut River Basin, 86% of the basin's population is served by municipal water supplies as compared to a national average of 75%. The distribution of the population which utilizes community supplies is shown on the following table:

TABLE 3

POPULATION AND WATER SUPPLY DEPENDENCY
CONNECTICUT RIVER BASIN
1960

Basin Subdivision	Total (1,000)	Served by Community Systems (1,000)	Percent Served
CRB I	54	26	87
CRB II	38	18	47
CRB III	86	65	76
CRB IV	74	41	55
CRB V	662	622	94
CRB VI	790	674	85
TOTAL	1,680	1,436	86 (ave.)

This tabulation indicates that the percent of the population of each of the subareas which utilize municipal systems range from 47 to 94%. In general, the population in the basin subareas located in Vermont (CRB II and CRB IV) are less reliant on municipal water systems than are other basin subdivisions.

The two metropolitan areas in the basin, Hartford and Springfield, contain 48% of the total population of the basin and account for 56% of the population which is served by municipal systems. Other areas of the basin, although not metropolitan, support heavy concentrations of population. Twelve such additional areas combined for an additional 30% of the population of the basin and 35% of the basin population served by municipal systems. All 14 areas are shown on Table 4.

Within each of the basin's subdivisions there are centers of populations which exert a significant portion of the demand on the municipal systems. In the Connecticut River Basin, 14 such areas accounted for approximately 87% of the total water supplied from municipal systems and constituted anywhere from 38 to 98% of the municipal water supplied in each of the basin subdivisions. These areas are shown on Table 4.

Municipal water supplies are drawn from both ground and surface sources. In New England about 79% of the population dependent on municipal supplies obtain water from surface sources. These surface supplies, however, provide about 83% of the total municipal water supply. The sources of supply in the Connecticut River Basin as a whole follow the same general pattern which prevails throughout the nation and New England, that is, surface water sources serve more people and provide more water than ground water sources. Figure 3 indicates the sources of public supplies within the basin subareas. In general, these data indicate the reliance on surface supplies is more prominent in basin subdivisions CRB V and CRB VI and also that municipal sources of water in basin subdivision CRB II are predominantly ground water supplies.

It should be noted that the largest man-made water supply reservoir in the basin and in the world is Quabbin Reservoir with a capacity of 1,280,000 acre-feet. Other water supply reservoirs in the basin combine for a total capacity of 174,000 acre-feet. Water supply reservoirs are discussed in Appendix D and are listed by State in Appendix J.

While floods cannot be prevented, man has tried to control them by comprehensive design and construction of flood protection works at and above critical damage centers. In the Connecticut River Basin 16 reservoirs and 15 local protection works have been constructed by

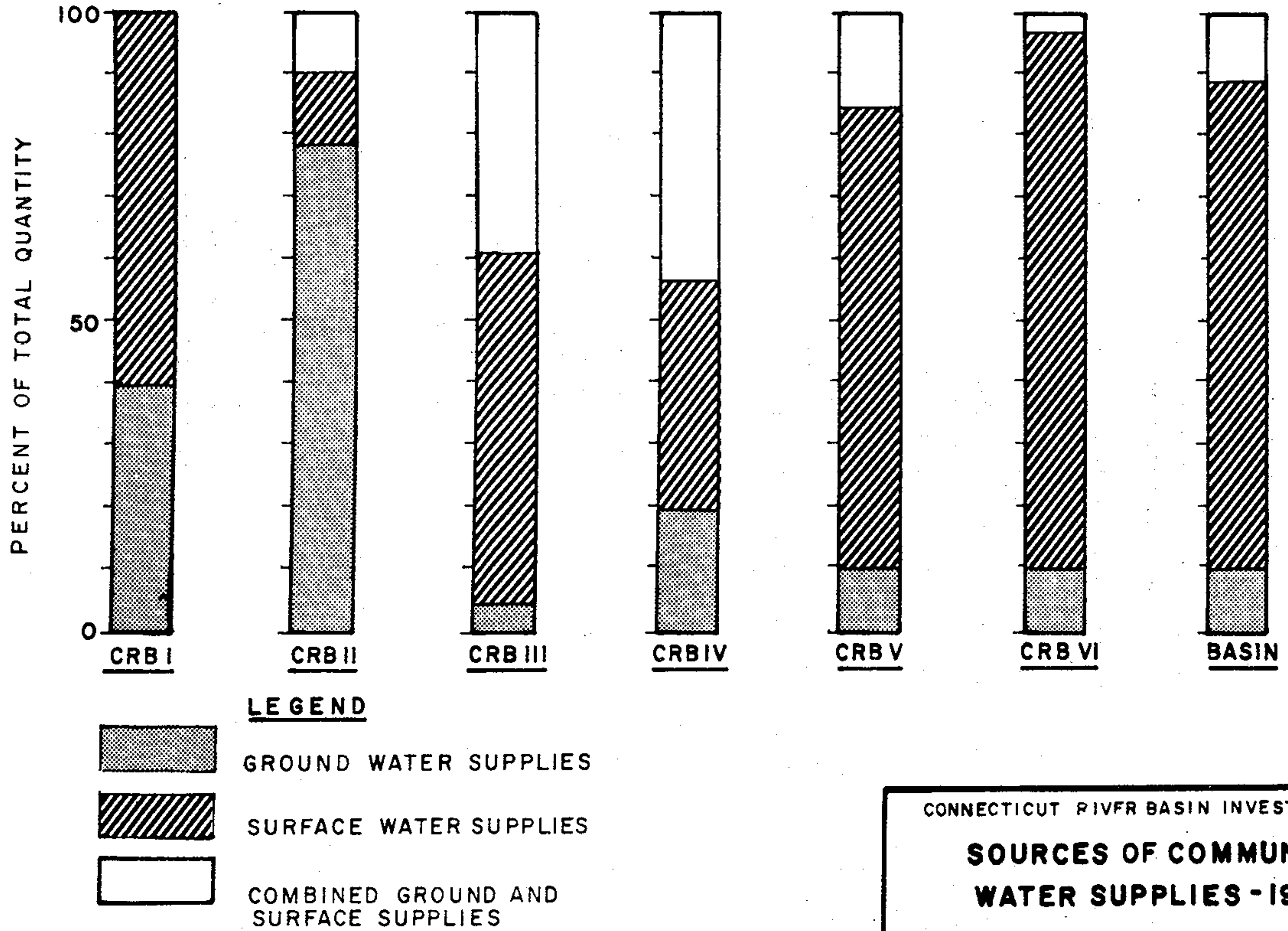
TABLE 4

MUNICIPAL WATER USE AREAS

CONNECTICUT RIVER BASIN

1960

Basin Subdivision and Area	Municipal Water Use, mgd	Percent of Basin Demand	Percent of Subbasin Demand
CRB I			
Littleton, N.H.	1.6	0.9	38.1
CRB II			
St. Johnsbury	1.7	1.0	58.6
CRB III			
Lebanon-Hanover, N.H.	2.8	1.6	37.3
Claremont-Newport, N.H.	1.5	0.8	20.0
Keene, N.H.	2.7	1.5	36.0
CRB IV			
Windsor, Vt.	0.4	0.2	7.4
Springfield, Vt.	1.3	0.7	24.1
Bellows Fall, Vt.	0.9	0.5	16.7
Brattleboro, Vt.	2.0	1.1	37.0
CRB V			
Northampton-Amherst, Mass.	8.1	4.5	9.6
Springfield, Mass.	60.0	33.6	71.0
CRB VI			
New Britain, Conn.	21.0	11.8	28.3
Hartford, Conn.	46.6	26.1	62.9
Middletown, Conn.	4.9	2.7	6.6
TOTAL	155.5	87.0	--



CONNECTICUT RIVFR BASIN INVESTIGATION

SOURCES OF COMMUNITY WATER SUPPLIES - 1960

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION BOSTON, MASS.

FIGURE 3

the Corps of Engineers. The reservoirs with over 500,000 acre-feet of flood storage reduce flood flows from nine of the Connecticut River tributaries and with the series of dikes, flood walls, and channel improvements, principally along the main stream, protect many highly developed downstream damage centers in the four States. These structures are described in Appendix M.

Eleven upstream watershed projects have been completed or are under construction. These locally-sponsored projects, authorized under the Watershed Protection and Flood Prevention Act (PL83-566), were planned and installed with the assistance of the Soil Conservation Service, Department of Agriculture. The 11 projects comprise a total of 222,800 acres or about 3.1 percent of the drainage area of the basin. Structural measures consist of 34 single- and multiple-purpose floodwater retarding structures with 33,000 acre-feet of floodwater and sediment storage and 2,000 acre-feet of additional storage for water supply, recreation, and fish and wildlife uses, and approximately 30 miles of channel improvement. Appendix F contains detailed descriptions of the existing programs and projects involving the Department of Agriculture.

The Connecticut River Basin contains many recreation-oriented facilities. For instance, there are two national forests, about 58 State parks, and approximately 97 State forests. Inventories of other State-managed recreational facilities within the Connecticut River Basin are contained in Appendix J of this report. These include such items as wildlife management, game farms, sanctuaries, recreation areas, fish hatcheries, State reservations, and public access areas. Figure 4 shows existing recreation areas in the basin, but a more complete discussion of recreational supply in the basin is discussed in Appendix H.

Since 1872 the Federal Government has made numerous navigational improvements on the Connecticut River largely below Hartford, Connecticut. These have consisted of a Federal channel 52 miles long from Long Island Sound to Hartford with anchorage improvements in North Cove, Wethersfield Cove, and along the main channel opposite Essex, Connecticut. Non-Federal navigation projects consist of the still operable Windsor Locks Canal which permits passage of shallow draft boats from the lower Connecticut around Enfield Rapids into the Enfield Pool. Although at one time there were navigation locks and boat passage around several of the great

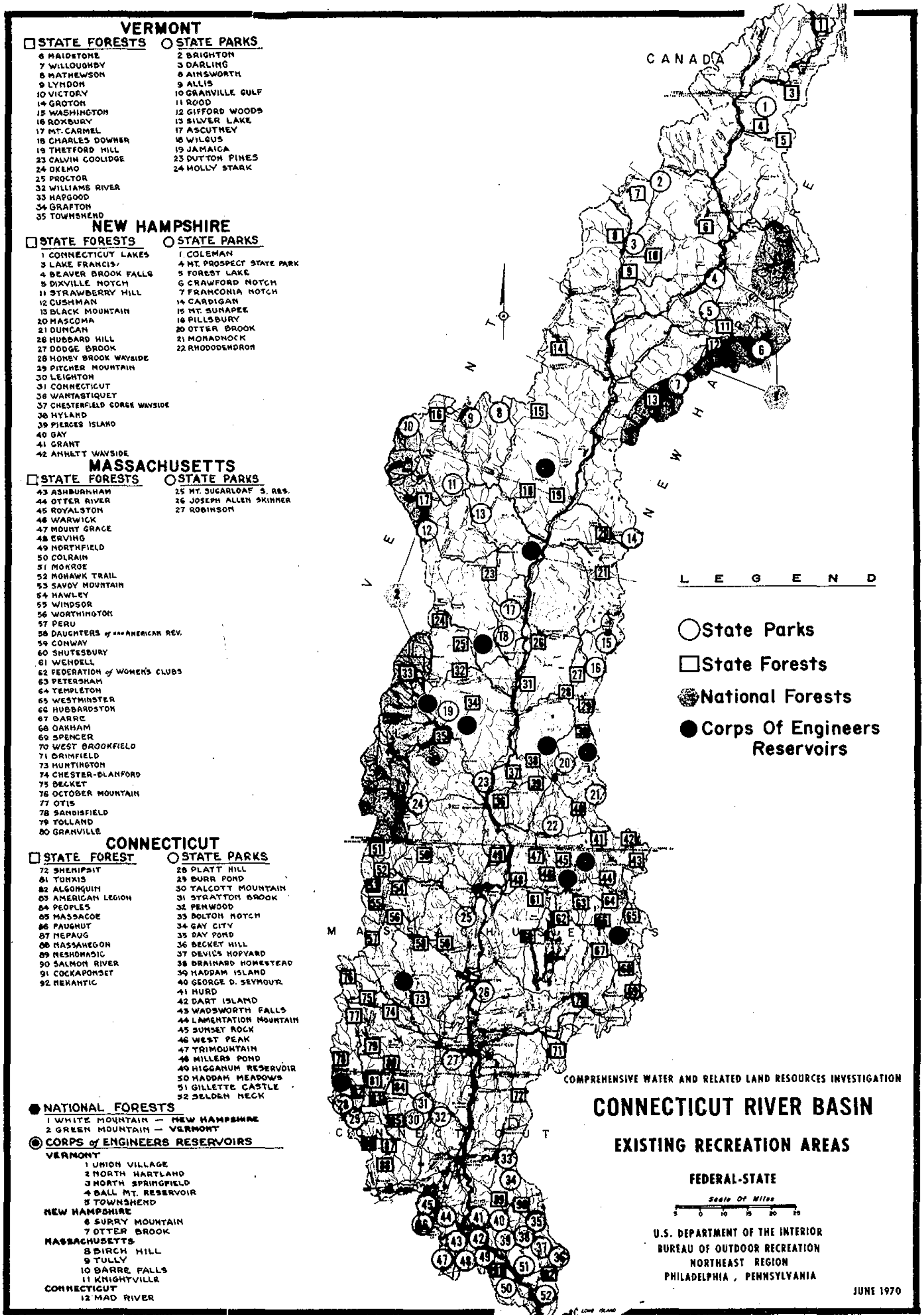

VERMONT
STATE FORESTS
6 MAIDSTONE
7 WILLOUGHBY
8 MATHEWSON
9 LYNDON
10 VICTORY
14 GROTON
15 WASHINGTON
16 ROXBURY
17 MT. CARMEL
18 CHARLES DOWNER
19 THETFORD HILL
23 CALVIN COOLIDGE
24 OKEMO
25 PROCTOR
32 WILLIAMS RIVER
33 HAPGOOD
34 GRAFTON
35 TOWNSHEND
STATE PARKS
2 BRIGHTON
3 DARLING
8 AINSWORTH
9 ALLIS
10 GRANVILLE GULF
11 ROOD
12 GIFFORD WOODS
13 SILVER LAKE
17 ASCUTNEY
18 WILGUS
19 JAMAICA
23 DUTTON PINES
24 MOLLY STARK
NEW HAMPSHIRE
STATE FORESTS
1 CONNECTICUT LAKES
3 LAKE FRANCIS
4 BEAVER BROOK FALLS
5 DIXVILLE NOTCH
11 STRAWBERRY HILL
12 CUSHMAN
13 BLACK MOUNTAIN
20 MASCOMA
21 DUNCAN
26 HUBBARD HILL
27 DODGE BROOK
28 HONEY BROOK WAYSIDE
29 PITCHER MOUNTAIN
30 LEIGHTON
31 CONNECTICUT
36 WANTASTIQUET
37 CHESTERFIELD GORGE WAYSIDE
38 HYLAND
39 PIERCES ISLAND
40 GAY
41 GRANT
42 ANNETT WAYSIDE
STATE PARKS
1 COLEMAN
4 MT. PROSPECT STATE PARK
5 FOREST LAKE
6 CRAWFORD NOTCH
7 FRANCONIA NOTCH
14 CARDIGAN
15 MT. SUNAPEE
16 PILLSBURY
20 OTTER BROOK
21 MONADNOCK
22 RHODODENDRON
MASSACHUSETTS
STATE FORESTS
43 ASHBURNHAM
44 OTTER RIVER
45 ROYALSTON
46 WARWICK
47 MOUNT GRACE
48 ERVING
49 NORTHFIELD
50 COLRAIN
51 MONROE
52 MOHAWK TRAIL
53 SAVOY MOUNTAIN
54 HAWLEY
55 WINDSOR
56 WORTHINGTON
57 PERU
58 DAUGHTERS of the AMERICAN REV.
59 CONWAY
60 SHUTESBURY
61 WENDELL
62 FEDERATION of WOMEN'S CLUBS
63 PETERSHAM
64 TEMPLETON
65 WESTMINSTER
66 HUBBARDSTON
67 BARRE
68 OAKHAM
69 SPENCER
70 WEST BROOKFIELD
71 BRIMFIELD
73 HUNTINGTON
74 CHESTER-BLANFORD
75 BECKET
76 OCTOBER MOUNTAIN
77 OTIS
78 SANDISFIELD
79 TOLLAND
80 GRANVILLE
STATE PARKS
25 MT. SUGARLOAF S. RES.
26 JOSEPH ALLEN SKINNER
27 ROBINSON
CONNECTICUT
STATE FOREST
72 SHENIPSIT
81 TUNXIS
82 ALGONQUIN
83 AMERICAN LEGION
84 PEOPLES
85 MASSACOE
86 PAUGNUT
87 NEPAUG
88 NASSAHEGON
89 NESHOBASIC
90 SALMON RIVER
91 COCKAPONSET
92 NEHANTIC
STATE PARKS
28 PLATT HILL
29 BURR POND
30 TALCOTT MOUNTAIN
31 STRATTON BROOK
32 PENWOOD
33 BOLTON NOTCH
34 GAY CITY
35 DAY POND
36 BECKET HILL
37 DEVIL'S HOPYARD
38 BRAINARD HOMESTEAD
39 HADDAM ISLAND
40 GEORGE D. SEYMOUR
41 HURD
42 DART ISLAND
43 WADSWORTH FALLS
44 LAMENTATION MOUNTAIN
45 SUNSET ROCK
46 WEST PEAK
47 TRIMOUNTAIN
48 MILLERS POND
49 HIGGANUM RESERVOIR
50 HADDAM MEADOWS
51 GILLETTE CASTLE
52 SELDEN NECK
NATIONAL FORESTS
1 WHITE MOUNTAIN — NEW HAMPSHIRE
2 GREEN MOUNTAIN — VERMONT
CORPS of ENGINEERS RESERVOIRS
VERMONT
1 UNION VILLAGE
2 NORTH HARTLAND
3 NORTH SPRINGFIELD
4 BALL MT. RESERVOIR
5 TOWNSHEND
NEW HAMPSHIRE
6 SURRY MOUNTAIN
7 OTTER BROOK
MASSACHUSETTS
8 BIRCH HILL
9 TULLY
10 BARRE FALLS
11 KNIGHTVILLE
CONNECTICUT
12 MAD RIVER
CANADA
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
LEGEND
State Parks
State Forests
National Forests
Corps Of Engineers Reservoirs
COMPREHENSIVE WATER AND RELATED LAND RESOURCES INVESTIGATION
CONNECTICUT RIVER BASIN
EXISTING RECREATION AREAS
FEDERAL-STATE
Scale Of Miles
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
NORTHEAST REGION
PHILADELPHIA, PENNSYLVANIA
JUNE 1970

FIGURE 4

falls on the Connecticut River such as South Hadley, Turners Falls, Bellows Falls, Sumner's Falls, and Wilder, these are no longer operable and only remnants give evidence of their earlier existence.

The present generated waste load of the basin represents a biochemical oxygen demand of almost 500,000 pounds each day. Future waste loads are anticipated to increase in magnitude although the amount of increase could be affected by changes in industrial processes or advances in technology. Domestic and municipal waste loads will become greater on a per capita basis due to anticipated greater affluence of basin residents. Increases due to affluence will occur from use of such equipment as garbage disposal units as well as expansion of present sewerage systems.

Estimated waste loads to basin streams are shown in Table 5 and waste treatment by sub-basin areas is shown in Table 6. A brief discussion of the projected waste loads and their effect on water quality for the period 1980 through 2020 is contained in Section V of this appendix and in greater detail in Appendix D of this report.

Based on 1963 information published by the Department of Health, Education, and Welfare less than 30% of the communities in the Connecticut River Basin are sewered. On a State-by-State basis this amounts to 14 communities in Vermont, 20 in New Hampshire, 26 in Connecticut, and 39 in Massachusetts. In Vermont 14 systems served 41,800 people or about 37% of the total population of CRB II and IV. In New Hampshire, 20 systems served 55,000 people or 47% of the total population of CRB I and III. In Massachusetts 47 systems served 39 towns and a population of 457,300 which was 69% of the sub-basin CRB V. In Connecticut 31 systems in 26 towns served 454,800 people or 58% of the population in sub-basin CRB VI. A list of the communities served in 1963 by one or more municipal sewer systems can be found in Table 7.

At the present time, approximately 12% of the total of almost 500,000 pounds of waste loading is removed by various forms of treatment prior to discharge to the receiving waters. Biological treatment methods by secondary treatment which have the capability of removing 85 to 90% of the biochemical oxygen demand are presently practicable and commonly used throughout the nation.

The basin States have taken steps to provide treatment of municipal and industrial wastes. In the Connecticut River Basin, the States have implemented plans to meet State water quality standards. The

TABLE 5

WASTE LOADS TO BASIN STREAMS

1960

Pounds Per Day BOD_5

Basin Subdivision and Stream	Municipal	Industrial	Percent Subbasin Total
CRB I			
Upper Ammonoosuc	255	154,000	97.5
Israel	250	-	Nil.
Johns	230	-	Nil.
Ammonoosuc	975	1,670	1.7
Connecticut	425	-	0.3
Subtotal	2,135	155,670	
CRB II			
Nulhegan	-	-	Nil.
Pauls Stream	-	-	Nil.
Passumpsic	1,660	-	33.4
Wells	-	120	2.4
Waits	-	-	Nil.
Ompompanoosuc	-	-	Nil.
Connecticut	375	2,820	64.2
Subtotal	2,035	2,940	
CRB III			
Mascoma	895	4,100	20.7
Sugar	1,870	8,615	43.5
Cold	-	-	Nil.
Ashuelot	2,240	5,360	31.5
Connecticut	995	-	4.1
Subtotal	6,000	18,075	
CRB IV			
White	650	750	13.4
Ottauquechee	170	-	1.6
Black	1,085	910	19.0
Williams	85	-	0.8
Sacketts Br.	-	2,020	19.4
Saxtons R.	-	400	3.8
West	135	-	1.3
Connecticut	3,350	890	40.8
Subtotal	5,475	4,970	

TABLE 5 (Continued)

Basin Subdivision and Stream	Municipal	Industrial	Percent of Subbasin Total
CRB V			
Millers	3,410	9,200	9.5
Deerfield	2,410	7,645	7.6
Mill	-	-	Nil.
Manhan		485	0.4
Chicopee	5,850	22,510	21.2
Westfield	2,945	9,075	8.8
Connecticut	48,210	21,175	52.4
Subtotal	62,825	70,090	
CRB VI			
Scantic	150	1,450	1.7
Farmington	6,825	195	7.4
Hockanum	9,130	3,760	13.7
Salmon Br.	-	275	0.3
Salmon R.	-	150	Nil.
Hubbard Br.	-	1,240	1.3
Connecticut	63,800	7,610	75.7
Subtotal	79,905	14,680	
TOTAL	158,375	266,425	

TABLE 6

TREATMENT OF MUNICIPAL AND INDUSTRIAL WASTES

Pounds Per Day BOD_5

1960

Basin Subdivision	Industrial			Municipal		
	Raw	After Treatment	Percent Removed	Raw	After Treatment	Percent Removed
CRB I	155,670	155,670	Nil.	2,355	2,135	9
CRB II	2,940	2,940	Nil	2,035	2,035	Nil.
CRB III	18,075	18,075	Nil.	7,385	6,000	18
CRB IV	4,970	4,970	Nil.	5,980	5,475	8
CRB V	70,090	70,090	Nil.	84,930	62,825	26
CRB VI	15,695	14,680	1	112,290	79,905	29
Total	267,440	266,425	Nil.	214,975	158,375	26

TABLE 7

COMMUNITIES SERVED BY SEWER FACILITIES

CONNECTICUT

Bristol	Manchester (2)	Granby
Hartford	Plainville	Newington
Middletown (2)	West Hartford	Portland
New Britain	Wethersfield (2)	Rocky Hill
Winchester (Winsted)	Windsor	Simsbury (3) (incl. Tariffville)
East Hartford	Avon (2)	Vernon (Rockville)
Bloomfield	Berlin	Windsor Locks
Farmington	East Windsor	
Glastonbury	Enfield	

31 systems in 25 communities
Population in the communities served = 590,500
Population served = 454,800

Percent of CRB VI population = 57.6%

NEW HAMPSHIRE

Keene	Colebrook	Hanover
Claremont	Lancaster	Haverhill
Lebanon	Northumberland	Lisbon
Charlestown	Stewartstown	Littleton
Newport	Startford	Hinsdale
Sunapee	Whitefield	Walpole
Unity	Bethlehem	

No. of systems = 20
Population of towns served = 83,600
Population served = 55,000

Percent of CRB I and III population = 47.4%

TABLE 7 (Continued)

MASSACHUSETTS

Chicopee	East Longmeadow	Palmer
Gardner	Easthampton	Royalston (2) (incl. So. Royalston)
Holyoke	Erving	Russell (2) (incl. Woronoco)
Northampton	Greenfield	Shelburne
Springfield	Hardwick (2) (vlg. of Gilbertsville and Wheelright)	Sunderland
Westfield	Hatfield	South Hadley
Agawam	Huntington	Spencer (2)
Amherst	Ludlow	Templeton (vlg. of Baldwinville)
Athol	Longmeadow	Ware
Barre (2) (incl. So. Barre)	Montague (2) (incl. Montague City)	Warren
Belchertown	North Brookfield	West Springfield
Buckland	Orange	Wilbraham
Chester		Winchendon
Deerfield (2) (incl. vlg. of So. Deerfield)		

46 systems in 39 towns
Population of towns served = 599,500
Population served = 457,300

Percent of CRB V population = 69%

VERMONT

Bethel	Readsboro	Newbury
Bradford	St. Johnsbury	Rockingham
Brattleboro	Springfield	Woodstock
Randolph	Ludlow	Windsor
Hartford	Lyndon	

No. of systems = 14
Population of towns served = 51,800
Population served = 41,800

Percent of CRB II and IV population = 37.3%

type of treatment and the date of implementation varies throughout the basin. Generally Connecticut and Massachusetts schedules require installation of secondary treatments by 1972 and 1974, respectively. The plans submitted by Vermont and New Hampshire would provide for a mixture of both primary and secondary plants by 1970 and 1977, respectively. The Secretary of the Interior has not yet approved certain parts of these implementation plans, but the exceptions are under continuing negotiation. In the five-year period from 1963 to 1968, Federal construction grants were made in the basin States for projects having a total eligible cost of approximately $190 million. Federal grants during this period amounted to approximately $39 million.

B. NATURAL ENVIRONMENT

The Connecticut River forms in the mountains above the Fourth Connecticut Lake near the Canadian border, and it flows some 400 miles through a basin 280 miles long and 60 miles wide. The basin encompasses an area of 11,250 square miles in four States and a small portion of one Canadian Province. Major tributaries include the Ammonoosuc, Ashuelot, Millers, and Chicopee Rivers entering from the east; the Passumpsic, White, West, Deerfield, Westfield, and the Farmington Rivers entering from the west. Daily flow of the Connecticut averages nearly 16,000 cubic feet per second. However, it has ranged as high as 282,000 and as low as 971 cfs. In the spring, daily flows average over 24,000 cfs but drop to under 5,000 in late summer.

1. Climate

The climate of the Connecticut River Basin varies considerably depending on the elevation and location with respect to the coast. The valley is subjected to frequent but generally short periods of heavy precipitation since it lies in the path of prevailing westerlies and cyclonic storms. The central and lower portions of the valley are exposed to occasional coastal storms, some of tropical origin that travel up the Atlantic seaboard.

As noted in Appendix C - Hydrology, the average annual tempera-autre of the Connecticut River Basin is about 45° F. Average annual temperature ranges from about 50° F. at points in the southern part near the coast to less than 40° F. at the higher elevation in the central and northern portions. Average monthly temperatures vary widely throughout the year, from between 61 and 73° F. in July and August to between 11 and 28° F. in January and February. Average daily temperatures range from occasional highs in the upper 90's to infrequent lows of minus 15° F. in the south and minus 25° F. or lower in the north.

2. Topography

The upper part of the Connecticut River Basin above Fifteen Mile Falls near Littleton, New Hampshire is in the northern part of the White Mountain section of the New England Physiographic Province. From Littleton, New Hampshire to Turners Falls, Massachusetts the basin lies within the New England Upland. In the 90-mile reach between Turners Falls, Massachusetts and Middletown, Connecticut the basin is in the Connecticut Lowland section. At Middletown, the river turns southeast, leaves the Lowland, and cuts through the southern portion of the New England Upland in a narrow valley to the sea.

The entire basin of the Connecticut River is maturely dissected with the river flowing throughout most of its course in a wide, open valley with well-developed flood plains above which rise glacial terraces tiered on the valley walls. Rugged mountains stand out boldly above the terraced valley in the White Mountain section. In its course through the Upland section, the main river winds between rounded, irrigular hills and ridges. The Connecticut Lowland section of the basin is a region of subdued hills which extend on both sides of the broad, terraced river valley to the borders of the inclosing Upland. Projecting above the eroded hills of the Lowland section are bold ridges of relatively resistant trap rock which constitute the major topographic feature of this region. The topography of the entire basin has been modified by glaciation which scraped the tops from the bedrock hills and filled the valleys with glacial detritus. There was, however, apparently little actual diversion of drainage by the glacier in the Connecticut Basin. The major effect of the glacial fill in the valleys has been to raise the streams from their old beds, thereby permitting the development of present channels which have little or no relation to the underlying configuration of the old valley in the bedrock.

3. Geology

The New Hampshire-Vermont portion of the basin is underlain by bedrocks which are generally Paleozoic in age. These rocks consist of Ordovician, Silurian, and Devonian sediments and Devonian and Carboniferous igneous rocks which have been folded and crumpled along axes running north-northeast to south-southwest. In addition to intense folding, thrust faults have developed which underlie and parallel the Connecticut River Valley throughout some or part of its length. The original sedimentary rocks have been altered to schist, quartzite, slate, gneiss, and other metamorphic rocks. Many of the igneous rocks have been changed to gneiss, serpentine, or otherwise metamorphosed.

Throughout Massachusetts and most of Connecticut, the river flows through the Triassic Lowland which is underlain by sandstone, arkose, conglomerate, and shale with interbedded basalt flows and diabase sills, usually known as "trap" rock. The Triassoc rocks have been faulted and tilted so that subsequent erosion has uncovered the relatively resistant trap rock and removed some of the surruonding weaker sediments to leave the trap standing out in prominent ridges. Where the river turns southeastward at Middletown, Connecticut, it leaves the soft rocks of the Triassic Lowland and flows in a valley excavated in relatively hard schist, gneiss, and granite.

The overburden in the entire Connecticut River Basin is mainly glacial till consisting of a mixture of clay, silt, sand, gravel, cobbles, and boulders. The till is generally thick in the valleys and thinner on the hills. The till may be absent on many steep slopes and on the tops of narrow-crested hills or mountains, leaving the bedrock exposed. Overlying the till in the valleys are extensive aqueo-glacial deposits which generally form very prominent topographic features throughout the basin. These deposits include stratified materials laid down mainly in glacial lakes and, to a lesser extent, by glacial streams. The lake deposits include the terraces, deltas, and varved clay deposits of the basin. The terraces and deltas are composed of bedded sands and gravels. The varved or seasonally banded clays, which may be very thick at locations of former glacial lakes, consist of clay and silt and are overlain by sand or sand and gravel.

4. Ecology

The ecosystem of the Connecticut River Basin is described in Appendix O of this report. Briefly in the Connecticut River Basin there are four zones: the Sub-Artic Zone, the Boreal Forest, the Temperate Hardwood Forest, and Estuarine Zone. Each contains a specialized system of plants and animals which have evolved through the years by means of climate and elevation.

a. Sub-Artic Zone

The Sub-Artic Zone, which comprises less than 1/10 of 1% of the total area of the basin, is characterized by a treeless area of heath and a sparcity of animal life. The prime example of this zone is Mount Washington.

b. Boreal Forest

The Boreal Forest is found at lower elevations and is characterized by spruce fir associations.

c. Temperate Hardwood Forest

The Temperate Hardwood comprises the major portion of the basin and is characterized by hemlock-deciduous hardwood forest found in the lower portion of the basin.

d. Estuarine Zone

The fourth zone, the Estuarine Zone, is found in the area close to the marine environment where the tidal waters extend upstream to the vicinity of Hartford, Connecticut. This zone is characterized by the marine-affected climate, stream side meadows, and tidal salt marshes.

The Sub-Arctic Zone because of its small area and its unique character should be preserved for scientific study and public use for all time. The remaining life zones comprised increasingly greater areas of the Connecticut River Basin and have the most potential for use and exploitation by man. Care must be taken to insure that our use will not contribute to the degradation or destruction of their values.

C. HISTORICAL AND CULTURAL DEVELOPMENT

Since the discovery of the Connecticut River in 1614 by Adrian Block, the river has maintained an active and growing economy. Block established a trading post on the site of present day Hartford and claimed a broad territory for his native country. English settlements followed in the 1630's. During this period of settlement, both the Dutch and the English formed precarious alliances with the neighboring Indian tribes, leading to clashes for power and control. In 1650, the Hartford Treaty defined the boundaries of Indian, Dutch, and English holdings and ushered in a short period of relative peace. War again erupted between the two European powers in 1652. It was a brief conflict and forced the Dutch to abandon their claim to the river.

The Connecticut colonists manifested their spirit of independence at an early date and were proud of their colonial charter, which allowed them more freedom and independent action than most of the other American colonies. This sense of freedom and independence has become a traditional characteristic of the natives of the Connecticut Basin.

The influence of French to the north was exerted upon the Connecticut Valley and resulted in struggles between the French settlers in Canada and the English colonists in New England. The Connecticut River served as a waterway for the French and their Indian allies to raid the villages and settlements of the New England colonists. These raids led to periods of severe unrest which ended with the taking of Quebec by the English in 1759, and the signing of the Treaty of Paris in 1763.

The Revolutionary War left the valley virtually unscathed. Connecticut, Massachusetts, and New Hampshire were among the 13 original colonies which banded together to form the new Republic. In 1791 Vermont became the 14th State in the Union.

About one and one-half centuries ago the upper end of the valley became the scene of a remarkable footnote to early American history. The Indian Stream Republic, perhaps the smallest and shortest lived nation ever known in the Western Hemisphere, had its beginnings when three adventurers from New Hampshire acquired the upper valley from the Indians and settled it in 1796. About 1820, the State of New Hampshire acted to bring the area's almost 300 inhabitants within its fold. In resistance to the State's efforts, the residents of the area formed the Indian Stream Republic and appealed to Washington for recognition. The inhabitants were informed bluntly that they were within the territorial limits of both the United States and the State of New Hampshire. This attempt to establish an independent nation was abandoned in 1836, but traces of this indepencence are exhibited on occasion even today.

The economy of the Connecticut River Valley developed primarily on a basis of agriculture and trading. The Dutch founded a substantial trade with the Indians living along the river, dealing in furs and other goods. The English settlers from Plymouth Colony were attracted by the agricultural potential of a temperate climate and rich soil and were the first to build permanent villages in the valley. Their economy centered on livestock and farm produce and was largely self-sufficient. As the region expanded, shipbuilding, fishing, and lumbering became increasingly important. By the end of the 18th century, tanneries and small local mills thrived by processing leather, grain, lumber, and paper. The early 19th century saw the rapid growth of textile mills within the area.

With the development of mechanical equipment, New England's machine tool industry mushroomed, and factories making a wide range of articles from guns to pumps to sewing machines became a major factor in the economy of the area. The river served both as a source of power and as an economical way to transport raw materials and finished products.

The river was also the basal point of social and economic life. The first settlers chose the fertile plains near the river banks; the water served their household and farming needs, provided power for watersheels, and was their means of transportation. Because of this dependency on the river for food and transportation, many of the larger settlements were established on the flood plain of the main stem of the river. But, at the same time, the river acted as a barrier, hindering travel to and from established areas. Bridges became necessities to those who lived on either bank. In 1784 the first span, a toll bridge connecting Walpole, New Hampshire and Bellows Fall, Vermont was built. A need to develop a convenient method to extend travel down river around the falls prompted construction of the first canal in the United States at Bellows Falls, Vermont in 1792. The Nation's second and third canals were also constructed along the Connecticut at Turners Falls and South Hadley, Massachusetts. Today, Windsor Locks is the only functional canal remaining on the river. Built in 1829, it provides passage around Enfield Dam and Rapids.

Many inventions and innovations are also reflected in the Connecticut's waters. Residents along the river have always felt that the Connecticut was the birthplace of modern shipping. The first steam propelled boat was built in Windsor, Connecticut in 1787. Six years later, and 14 years before Fulton's steamboat, an improved version with a steam-turned paddlw wheel was constructed by Samuel Morey at Oxford, New Hampshire. In 1848 Samuel Colt established a factory in Hartford equipped with the most up-to-date machines for making his famous firearms. Numerous factories were built along the river during the 19th century, changing the face of much of the valley from rural countryside to a series of booming industrial towns.

D. ECONOMIC DEVELOPMENT

The first settlements on the main stem of the river were at Hartford, Windsor, and Wethersfield, Connecticut in 1635. Springfield, Massachusetts was started in 1636. These early communities were founded by Puritans from the Massachusetts Bay Colony. The social, economic, and spiritual influences which distinguished the Bay Colony were implanted in these towns. Farming was their first occupation. However, in the Connecticut River Valley as elsewhere, the number of farms and farm workers has dwindled and the importance of agriculture in the economy has declined during the last century. In 1910, 9.65% of the labor force in New England listed occupations in the agriculture category; by 1950 this had dropped to only 3.15%. Today the economy of the basin is a diverse mix of manufacturing, trade, finance, agriculture, and tourism, with higher education also being an important factor.

Industry in the basin varies from sub-basin to sub-basin. In CRB I paper, lumber, and veneer dominate and other wood products employ a large percentage of those working in manufacturing. The machinery industry is projected to have significant growth in CRB I although not be as prominent as in CRB IV. Paper is also projected to be a major source of employment growth after 1980. In summary, although manufacturing in CRB I is highly concentrated in a few industries which are anticipated to remain the primary sources of growth, a greater diversification of the manufacturing base is expected to take place.

In CRB II, manufacturing is chiefly concentrated in lumber, wood, paper, and machinery industries. Employment in the machinery and electrical machinery industry is projected to grow significantly; and by 2020, will constitute major industries second only to the paper and allied projects industry. Employment in the lumber and wood products industry is expected to decline slightly.

Textile and leather have been the traditional manufacturing industries in CRB III, however, machinery and electrical machinery have experienced vigorous growth in this area in the past 10 years and non-electrical machinery now stands out as a major employer. By 2020, machinery and electrical machinery industry will be the sub-area's largest manufacturing activity.

In CRB IV non-electrical machinery has been the sub-area's largest single manufacturing industry, employing a large percent of the manufacturing work force. The industry is presently concentrated in five or six large machine tool firms in the towns of Springfield and Windsor. It is projected that electrical and non-electrical machinery will account for more than half of the expected employment growth in the CRB IV manufacturing sector. Lumber and wood products which is presently the second largest industry has been declining and by 2020 its total employment will have fallen to a fraction of the 1960 level. In contrast, the paper and allied products industry, which is relatively small, will grow in importance after 1980 and by 2020 will account for a significant portion of the manufacturing industry.

The principal manufacturing employers in CRB V are non-electrical machinery, paper and allied products, textiles and fabricated metals. The paper, machinery and electrical machinery and chemical industries are anticipated to grow most rapidly in this area. In fact, the paper and chemical industries are projected to expand more rapidly in CRB V than in Massachusetts as a whole.

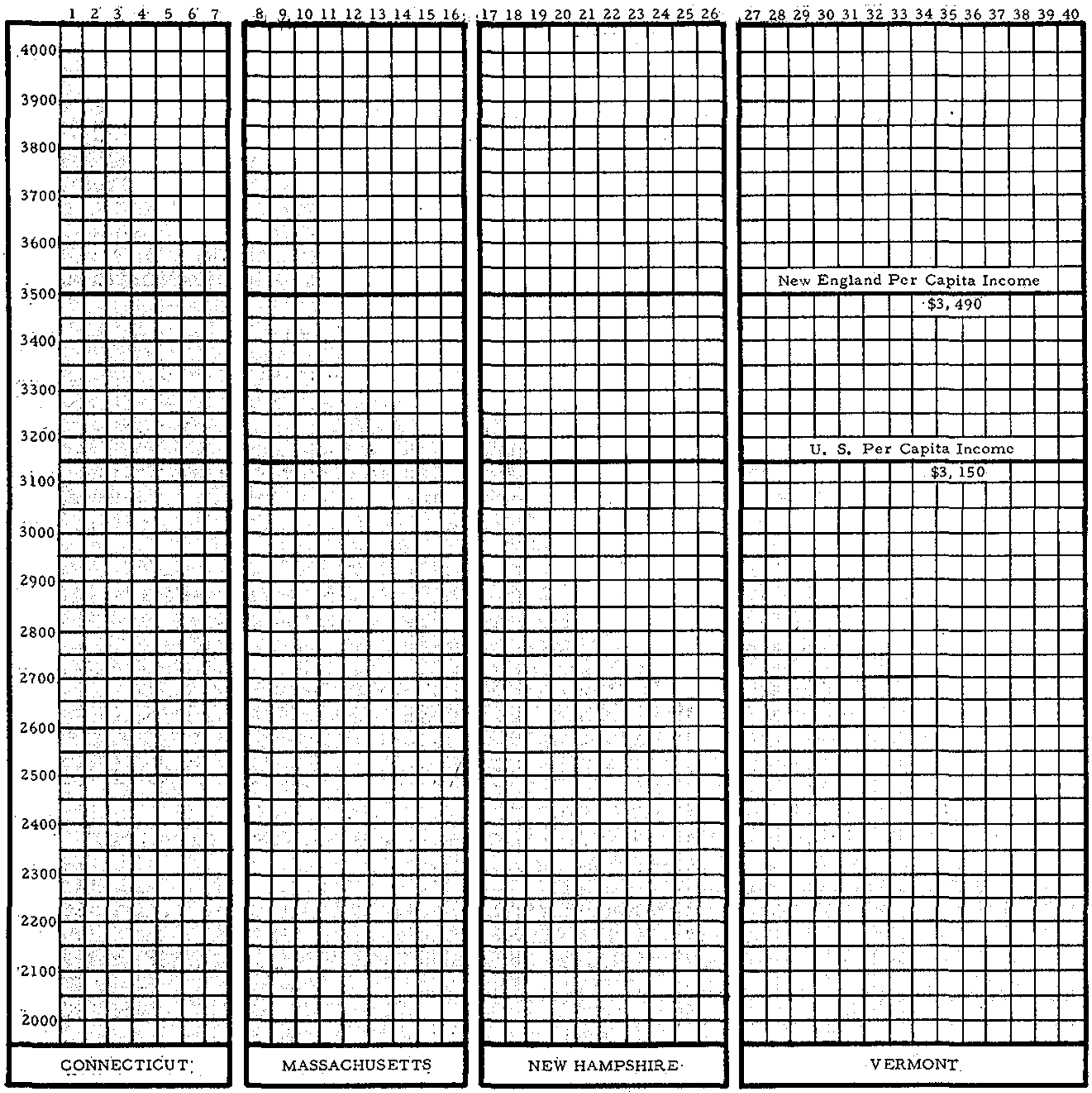
In CRB VI the most important manufacturing industries in 1960 were transportation equipment, non-electrical machinery, fabricated metal products and electrical machinery. Transportation equipment will continue to represent a significant percent of the future employment in manufacturing while machinery and electrical machinery are projected to have the fastest growth raté. Together these two industries will account for approximately one-half of the sub-area's manufacturing employment by 2020.

The New England economy will continue to prosper in the future according to available reports, but there are some serious problems which should be overcome. For instance, the concentration of highly technical industries and services are not distributed evenly across the region but are clustered in the southern portion of New England. Indications are that the same growth will continue to follow the same cluster pattern in the future. This concentration of jobs and population places a strain on the existing environment.

At the same time, the lack of economic opportunities in non-metropolitan New England has resulted in low income for those regions as well as inadequate services and facilities. These areas have suffered an out-migration even though they are the areas with the most attractive natural environment. An inspection of Table 8 in Section IV of this appendix reveals the general drop in the population increase between 1950 and 1960 as you move northward in the basin.

Reports issued by the New England Regional Commission indicate that future emphasis by the Commission will be directed toward designated growth centers in non-metropolitan areas. Also, within southern metropolitan areas, the Commission will emphasize the reduction of adverse effects of concentrated economic growth on the environment. The attempt will be to provide a balanced geographic growth and to prevent a continuation of these trends. The overloading of the environment in densely populated areas and increasing gaps between those who do not enjoy great economic advantage and those who do will place a growing burden upon the States and local Governments of New England.

Figure 5 shows the diversion in the level of per capita, personal income for the four States of the Connecticut River Basin. While the region as a whole has a higher per capita income than the nation, only a few areas exhibit per capita incomes in excess of the regional or national figure. For instance, there is a great disparity between per capita income levels in southern and northern portions of the Connecticut River Basin. With few exceptions, per capita income observations for New Hampshire and Vermont lie below both regional and national averages. Conversely, the majority of the per capita income levels in the southern basin States are at or above the national or regional levels.



1 Hartford, New London
2 New Haven, Waterbury Meriden
3 Bridgeport, Norwalk, Stamford
4 Litchfield
5 Windham
6 New London, Groton, Norwich
7 Middlesex

8 Nantucket
9 Pittsfield
10 Boston
11 Franklin
12 Dukes
13 Worcester, Fitchburg, Leominster
14 Barnstable
15 Springfield, Chicopee, Holyoke
16 Fall River, Bedford

17 Manchester
18 Cheshire
19 Strafford
20 Merrimack
21 Rockingham
22 Grafton
23 Belknap
24 Coos
25 Sullivan
26 Carroll

27 Burlington
28 Windsor
29 Windham
30 Bennington
31 Rutland
32 Washington
33 Caledonia
34 Addison
35 Essex
36 Orleans
37 Franklin
38 Grand Isle
39 Orange
40 Lamoille

Note: Numbers refer to both counties and urban regions.

PER CAPITA PERSONAL INCOME(1967) **FIGURE 5**

IV FACTORS OF CHANGE

A. SOCIAL AND DEMOGRAPHIC TRENDS

1. Population Growth

In 1960 the Connecticut River Basin had a population of approximately 1.68 million people. This represents a growth of approximately 15% during the decade 1950 - 1960. Nearly 84% of this population lives below the northern border of Massachusetts and 73% of the population in Massachusetts and Connecticut lives in the adjoining Standard Metropolitan Statistical Areas of Springfield-Chicopee-Holyoke-and Hartford. The combined population of these two SMSA's exceeds one million, and during the 1950 - 1960 decade, 86% of the basin's population growth took place in these two areas.

By comparison from Franklin County, Massachusetts northward in the basin, with the exception of Cheshire County, New Hampshire an examination of growth by counties shows little to no growth in the ten-year period preceding 1960. This is shown on Table 8. The three counties in northern Vermont, Essex, Orange, and Caledonia actually had a decrease in population. In northern New Hampshire, Coos and Grafton Counties, as a whole, showed slight increases but almost all of the growth in Coos County took place in the city of Berlin, which is outside the basin boundary. In Grafton County, the major portion of the growth took place in Hanover and Lebanon, which this study has included in Sub-basin Area CRB III, southern New Hampshire.

The counties in southern Vermont, Windsor and Windham and Sullivan County in New Hampshire as well as Franklin County in Massachusetts all show very slight growth in the order of two to six percent. Only Cheshire County, New Hampshire with a growth of 11.7% exhibited any significant increase. With this one exception the indication is that most of the growth has taken place in the southern metropolitan regions of the basin. On the basis of environmental aspects and available land, this is the section of the basin which can least accommodate the growth.

The population of the Connecticut River Basin is expected to increase approximately 85% during the 60-year projection period to a total of slightly over three million in the year 2020. Population projections for the Connecticut River Basin are based on information developed by the Office of Business Economics for the North Atlantic

TABLE 8

POPULATION 1950 - 1960
IN SELECTED BASIN COUNTIES

County	1950	1960	Change	Percent Change
New Hampshire				
Coos	35,932	37,140	1,208	+ 3.4
Grafton	47,923	48,857	934	+ 2.0
Sullivan	26,441	28,067	1,626	+ 6.1
Cheshire	38,811	43,342	4,531	+ 11.7
Vermont				
Essex	6,257	6,083	-174	- 2.8
Caledonia	24,049	22,786	-1,263	- 5.2
Orange	17,027	16,014	-1,013	- 6.0
Windsor	40,885	42,483	+1,598	+ 3.9
Windham	28,749	29,776	+1,027	+ 3.6
Massachusetts				
Franklin	52,747	54,864	2,117	+ 4.0
Hampshire	87,594	103,229	15,635	+ 17.8
Hamden	367,791	429,353	61,382	+ 16.7
Connecticut				
Hartford	539,661	689,555	149,894	+ 27.8
Middlesex	67,332	88,865	21,533	+ 31.9

Regional Resources Study. Adaptations were made of these figures so that they might be representative of the number of persons residing within the Connecticut River Basin tributary area without regard to political boundaries. More detailed information on population projections will be found in Appendix P of this report, however, Tables 9 and 10 show population break-downs by sub-basin and by State respectively, while Figure 6 illustrates the basin population projections as they relate to New England and the nation.

2. Personal Income

Total personal income in the basin is expected to rise over ten fold by the end of the projection period 2020. As noted previously, over this same period the population is expected to nearly double so that per capita personal income would rise over five fold. Figure 7 shows the rise in personal income and per capita income as compared to population. Table 11 shows the personal income by respective sub-basin areas and Table 12 shows the personal income projections by State.

3. Public Attitudes

The trend toward more leisure time and higher per capita income has resulted in a pronounced change in public attitudes and interests towards water and related land resources. Recreation-related services stand out as among the most important growing industries. Through contacts with organizations and private groups as well as views received at formal meetings and public hearings, certain opinions and preferences become apparent. An examination of correspondence and testimony received at hearings and meetings further confirms these preferences.

The most pressing concern seems to be for a higher water quality. Most people feel that the control of pollution is not progressing fast enough. Also there is a very evident concern for the environment and more awareness of the effects brought about by our rapidly changing way of life. People are more concerned with such factors as population pressures, open spaces, pollution of air, land, and water, need for restoration, and enhancement of natural resources than they have been in the past.

There is a sincere desire to satisfy regional water resource needs; however, there is a natural reluctance to share local resources with people of other areas, regions, or States. This is often evident for example, in the unwillingness to give up lands

TABLE 9

PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
POPULATION & HOUSEHOLDS (1,000's)

CRB		1960	1980	2000	2020
I	Population	30	33	35	39
	Urban	3	9	13	19
	Rural	27	24	22	20
	Households	9	9	10	11
II	Population	38	38	43	50
	Urban	6	7	10	11
	Rural	32	31	33	39
	Households	11	11	12	15
III	Population	86	94	102	124
	Urban	49	58	66	81
	Rural	37	36	36	43
	Households	27	29	32	38
IV	Population	74	87	109	122
	Urban	25	39	55	65
	Rural	49	48	54	57
	Households	22	26	32	37
V	Population	662	777	899	1132
	Urban	505	623	746	974
	Rural	157	154	153	158
	Households	195	229	264	343
VI	Population	790	971	1212	1643
	Urban	612	786	1030	1449
	Rural	178	185	182	194
	Households	235	286	357	498
TOTALS					
	POPULATION	1680	2000	2400	3110
	URBAN	1200	1522	1920	2599
	RURAL	480	478	480	511
	HOUSEHOLDS	499	590	707	942

TABLE 10

PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
POPULATION & HOUSEHOLDS BY STATE (1,000's)

State		1960	1980	2000	2020
N. H.	Population	116	127	137	163
	Urban	52	67	79	100
	Rural	64	60	58	63
	Households	36	38	42	49
VT.	Population	112	125	152	172
	Urban	31	46	65	76
	Rural	81	79	87	96
	Households	33	37	44	52
MASS.	Population	662	777	899	1132
	Urban	505	623	746	974
	Rural	157	154	153	158
	Households	195	229	264	343
CONN.	Population	790	971	1212	1643
	Urban	612	786	1030	1449
	Rural	178	185	182	194
	Households	235	286	357	498
CRB TOTALS					
	Population	1680	2000	2400	3110
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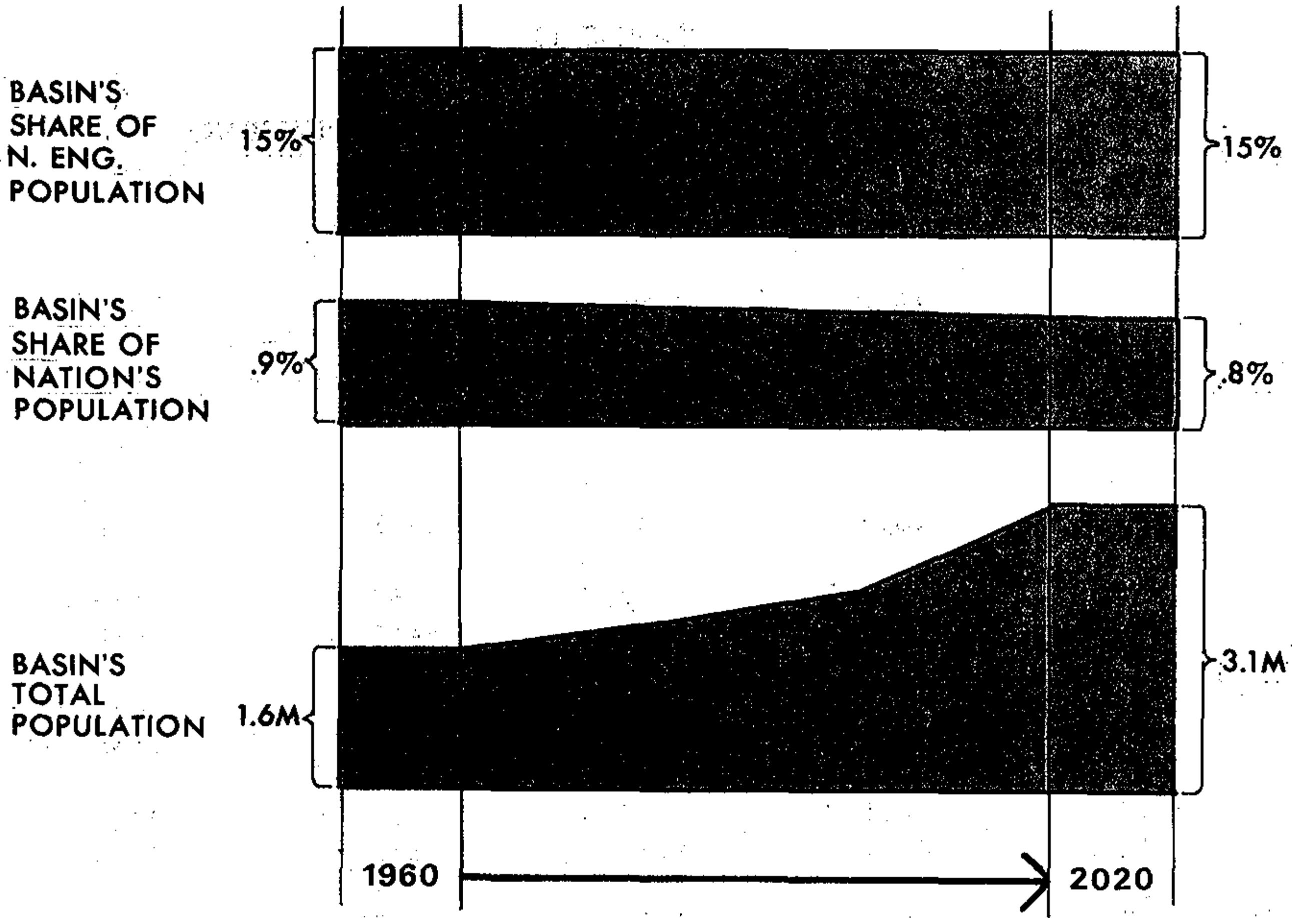
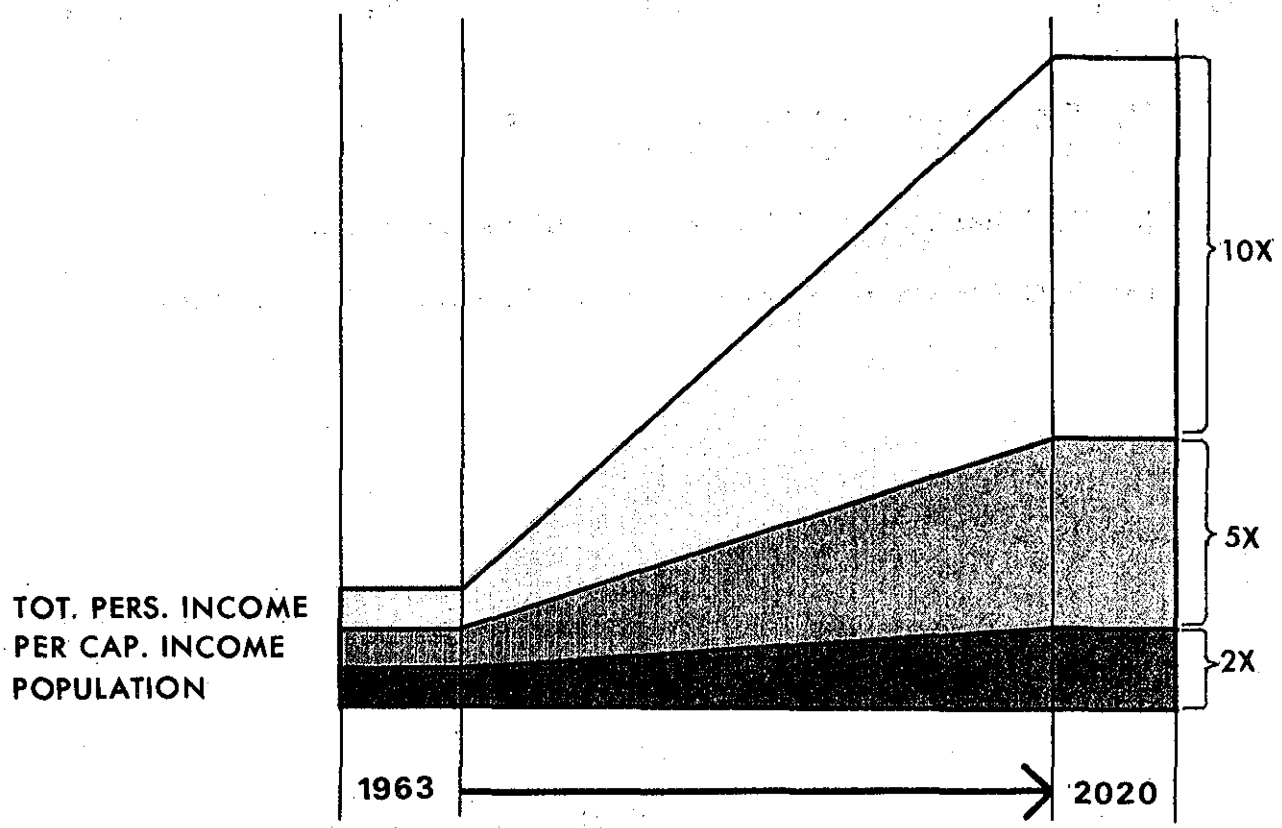


POPULATION

FIGURE 6



PERSONAL INCOME

FIGURE 7

TABLE 11

PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN
PERSONAL INCOME

CRB		1960 (1)	1980	2000	2020
I	PI (2) (3)	54.8	116.8	226.2	467.3
	P/C	1828	3540	646.2	11982
II	PI	69.5	134.5	277.9	599.1
	P/C	1828	3540	6462	11982
III	PI	157.2	332.8	659.1	1485.8
	P/C	1828	3540	6462	11982
IV	PI	135.3	308.0	704.4	1461.8
	P/C	1828	3540	6462	11982
V	PI	1696.0	3534.6	6847.7	14777.1
	P/C	2562	4549	7617	13054
VI	PI	2024.0	4417.1	9231.8	21447.7
	P/C	2562	4549	7617	13054
TOTAL PI		4136.8	8843.8	17947	40238.8

(1) Figures for 1960 were obtained from an interpolation of P/C figures supplied for 1959 and 1962.

(2) PI: Total Personal Income in millions (1958 dollars).

(3) P/C: Per Capita Personal Income in dollars (1958 dollars).

TABLE 12

PROJECTIONS FOR REFERENCE SUBDIVISIONS
CONNECTICUT RIVER BASIN

PERSONAL INCOME BY STATE

STATE		1960 (1)	1980	2000	2020
N.H.	PI (2)	212.0	449.6	885.3	1953.1
VT.	PI	204.8	442.5	982.3	2060.9
MASS.	PI	1696.0	3534.6	6847.7	14777.1
CONN.	PI	2024.0	4417.1	9231.8	21447.7
TOTAL	PI	4136.8	8843.7	17947.0	40238.8

(1) Figures for 1960 are based on an interpolation between data supplied for 1959 and 1962.

(2) P.I.: Total Personal Income in Millions (1958 Dollars).

for recreation, water supply, and particularly for flood control to protect downstream development which many people feel is unwisely permitted to occur in the flood plain.

Individuals throughout the basin are not sympathetic toward the public acquisition of land and the development of water resources as regional or national recreation attractions. This public sentiment is true regardless of political or physical boundaries and this condition long realized, in the Corps' water resources program, is now evident with regard to the Bureau of Outdoor Recreation's recommended National Recreation Area.

People are also always sympathetic toward building water bodies or providing land to satisfy the needs for out-of-State recreators. Much of the privately-owned basin land is posted against hunting, fishing or trespassing because the landowner does not feel he has sufficient control over the actions of transient users with respect to fires, indiscriminate cutting or littering of trash.

There is an apparent misunderstanding of the concept of the national recreation area plan of the Bureau of Outdoor Recreation particularly in the northern States. There is a belief that lands will be taken away to provide a place to play for out-of-Staters. Farmers upstate believe that since they have done the job all these years in keeping their natural environment, they do not need State or Federal help at this time.

Concerning water supply, there is a demonstrated provincial attitude. Many valley residents are opposed to diversions of water out of the basin to meet demands of the metropolitan Boston area. Although these diversions have been demonstrated to be small, certain interests continue to oppose the diversion and in some instances, exaggerate the consequences.

On the question of electrical energy needs, there were strong objections to the expansion of both nuclear fuel and fossil fuel thermal plants. People do not seem to realize the tremendous development of power supply that will be necessary to meet the expanded demands of an expanded population using more electrical equipment. They also seem to have forgotten recent shortage and voltage reductions.

B. ECONOMIC TRENDS

1. General

The Connecticut River Basin is characterized by a stable, prosperous economy. The States of the Upper Basin, Vermont and New Hampshire, were originally oriented towards agriculture and lumbering. In more recent times, these two States have grown rapidly in the recreation, tourism, and vacation industry while Connecticut and Massachusetts, starting with early industrial development, have made great strides in the manufacturing sector.

The economy of the basin is based on a diverse mixture of manufacturing trade, finance, agriculture, and tourism with higher education also being an important factor. As noted earlier, the basin is expected to shift from a manufacturing to a non-manufacturing emphasis. Figure 8 illustrates the shift in basin employment from manufacturing to non-manufacturing areas. This changing characteristic of the basin's economy is documented by manufacturing and non-manufacturing employment statistics and projections. Although the area economy remains more dependent on manufacturing than does the economy of the nation, this sector is declining and is projected to further decline relative to the non-manufacturing sector in importance as the source of employment in the basin. Employment in the region's manufacturing industry had, by 1960, declined to 40% of the area's total labor force. It is expected to further decline to 33% by 1980 and 24% by the year 2020. Manufacturing or traditional industrial activity, however, is still projected to be of greater importance to the regional economy than it is to the national economy and appears to be in a potentially strong position for the future as indicated in Appendix B of this report. Economic production per employee is expected to dramatically increase during the projection period, as depicted in Figure 9 . This will, in great part, be a result of the changing mix of manufacturing industries and the labor intensive to the capital intensive.

One significant effect of the projected basin population and the expected rise in personal income is the present and future impact of recreation expenditures in terms of income originated and its equivalent in employment. This is particularly true in the upper valley, an area which is well known for its summer and winter recreation. This area has already a high percentage of employment accounted for by the service sector and this reveals the importance of recreation related activity in this region. For example, in the counties of Grafton and Coos, New Hampshire 61% of the total employment in 1960, as indicated by table shown in Appendix B, was accounted for by the service sector and this figure is expected to rise to 74% by the year 2020. Recreation related activity is also important to the Vermont portion of the basin.

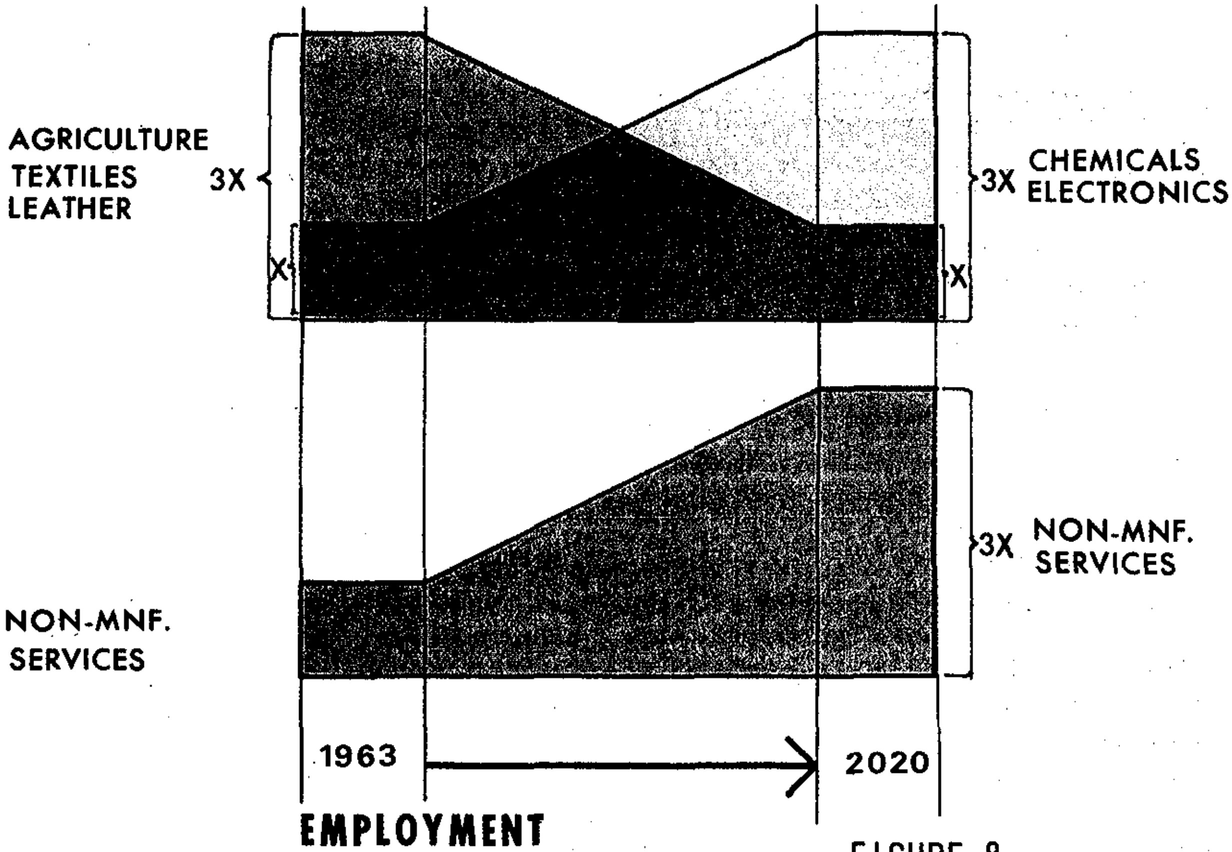


FIGURE 8

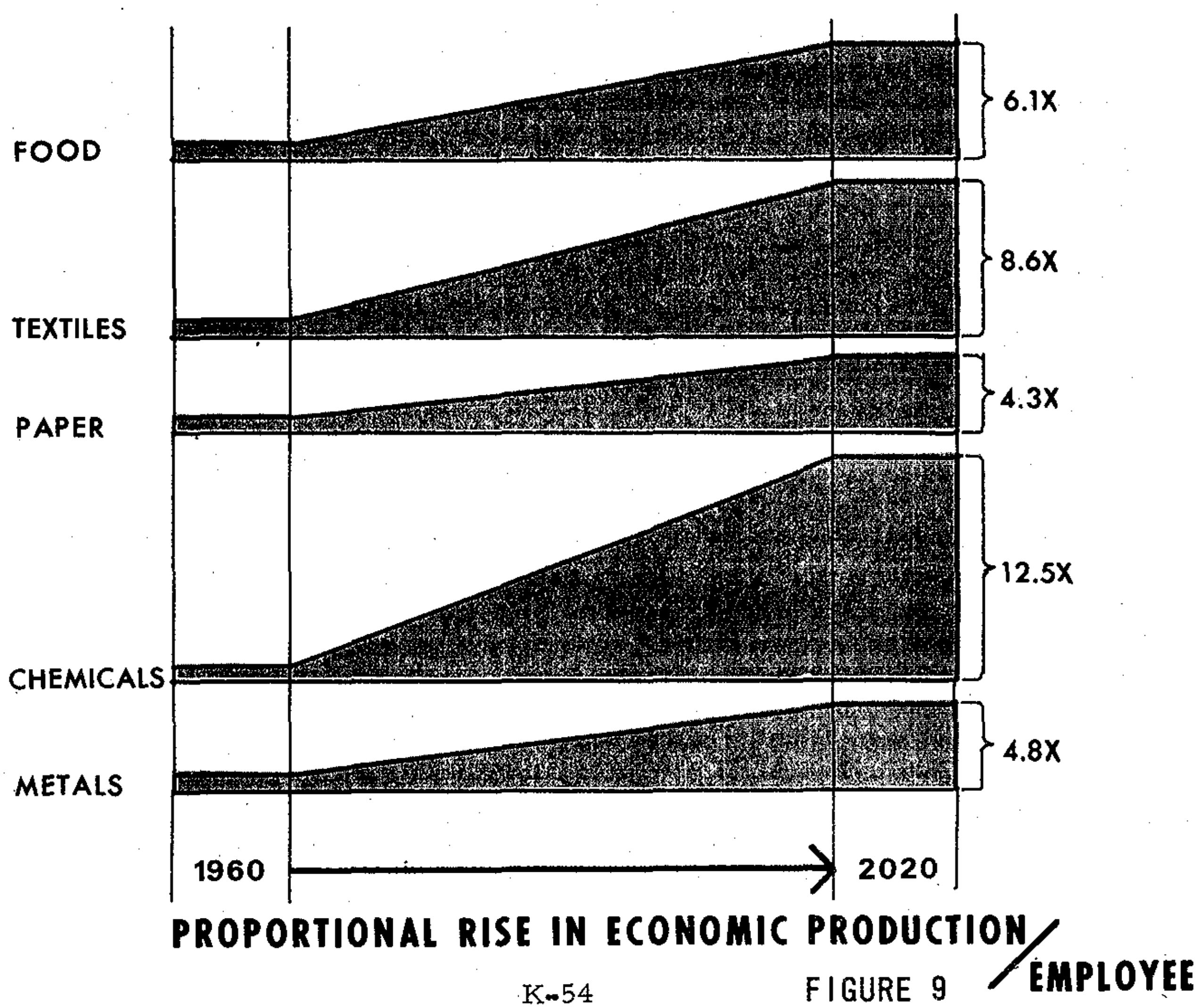


FIGURE 9

2. Agriculture and Forestry

Agriculture in the basin is closely related to nearby urban markets. Most of the production of the basin farms goes directly to the New England industrial cities in the form of dairy, poultry products, and vegetables. Milk is the principal dairy product, and dairying is the leading money product. According to the 1964 agricultural statistics, 39% of the farms in the Connecticut River Basin are dairy farms, 8% are poultry and livestock farms, 5% are crop-producing, and 48% are miscellaneous or unclassified. In the latter category, the majority are part-time farmers whose personal income is derived from urban employment or by others who maintain country residences or keep the land primarily for recreation purposes.

Agriculture in the Connecticut River Basin is undergoing a steady decrease in total employment, which is in part attributed to increasing urbanization. With the encroachment from metropolitan areas, especially prominent in lower parts of the basin, agriculture will become oriented toward production of commodities that do not necessitate heavy land requirements. Declines in the potato and tobacco industries are projected to continue while an overall increase in the dairy industry and vegetable output for fresh market is expected. Table 13 shows the distribution of farm types by sub-basin area.

TABLE 13

	Percent			
Reference Subdivision	Dairy	Other Livestock & Poultry	Field Crops	Miscellaneous & Unclassified
CRB I	46	6	3	45
CRB II	60	5	1	34
CRB III	26	10	0	64
CRB IV	40	9	3	48
CRB V	32	8	10	50
CRB VI	34	10	8	48
Basin Average	39	8	5	48

The major livestock enterprise is dairying which is projected to expand most in the upper part of the basin where resources will be more available. Improvements in management and technology will permit greater output in the future from less land. Land use for dairying practice has declined in recent years and is forecast to decline another 48% in the valley by 1980. The present and projected milk production by sub-basin area is shown in Table 14.

TABLE 14

MILK PRODUCTION

Reference Subdivision	1960	1980	2000	2020
	(in millions of pounds)			
CRB I	86	114	143	187
CRB II	265	347	440	574
CRB III	81	106	132	173
CRB IV	209	262	315	390
CRB V	273	281	287	298
CRB VI	219	230	243	275
Basin Total	1,133	1,340	1,560	1,897

The major crop enterprises of basin farms are hay-production which requires 80% of the harvested crop land, silage corn, tobacco, fresh market vegetables, fruit, and potatoes. The production of vegetables for fresh produce markets is projected to increase substantially in the basin. The area production of this item as well as the commercial production of apples is expected to expand more in the upper part of the basin, however, due to urban land pressures in the lower parts of the basin tobacco is expected to go out of production sometime after 1980 depending on institutional, political, and technological factors associated with the industry.

Management of poultry will probably permit greater output in future years. Basin-wide poultry production is second to dairy production. Egg production is expected to decrease slightly in upper portions of the basin and increase in the southern portion resulting in an overall increase of 37% by the year 2020. The annual agricultural employment (including agriculture related activity) of 41,350 in 1950 is expected to decline to about 38,000 by the year 2020. This is indicated in Figure 8.

The forest industry represents an important segment of the basin's economy. In 1966 preliminary and secondary forest-based industry employed 30,800 people with a total earnings of $153 million. In 1963 the value added in manufacturing forest production totalled some $280 million.

Employment is expected to exceed 37,000 by the year 2020. A decline is expected in employment within the lumber related group; however, substantial increases are expected in the wood using furniture industry and the paper and allied products group.

3. Manufacturing

Manufacturing developed on the lower portion of the Connecticut River Basin as the water power of the small tributary streams was utilized. Development of the larger tributaries followed, notably in the lower Farmington River and in the Westfield, Chicopee, Millers, and Deerfield Rivers. Developments in the upper regions of the valleys, which never attained the intensity of the industrial and commercial concentrations of the lower river, came much later. Principal streams in the upper valley from the manufacturing viewpoint were the Ashuelot, Sugar, Passumpsic, and the Black Rivers.

Employment in the metal working trades represent 62% of the manufacturing employment in Massachusetts and Connecticut portions of the basin and over one-third of all manufacturing employment in the upper valley. Personal income derived from manufacturing was the largest element in the basin's per capita income which was 5.8% above the national average in 1959. Value of product added by the basin's industrial complex exceeded $2.5 billion in 1963 and was growing at an annual rate of 3 1/2%. While the bulk rate of the produce was concentrated in the two southern States, especially Connecticut, value added exceeded $200 million in the States of the Upper and Middle Basin.

4. Services

Service in the basin is following the national pattern of growing with the prosperity of the region. Receipts from selected services amounted to $319 million in 1963 and the growth rate of receipts measured in constant 1958 dollars has been in excess of 8.8% annually for the previous seven years and the rate is accelerating. Employment in services in 1963 totalled 27,000.

Recreation and tourism contribute significantly to the basin's economy. The natural resources available for recreational opportunities are many and varied such as swimming, boating, camping, fishing, hunting, hiking, mountain climbing and nature studies. Both public and private recreation areas have been developed to provide outdoor recreation and have potential for further development. There are portions of 2 national forests, some 58 State parks, 97 State forests, and 12 Federal reservoirs in the basin area. There are also 65 private camping grounds. The total area is some 530,000 acres of which over two-thirds is in Vermont and New Hampshire. Total expenditures on tourism and recreation in 1967 amounted to over $115 million for the entire basin.

Higher education is also an increasingly important element in the valley's economy. All four basin States boast schools of higher learning, and colleges of national reputation. This contributes to the region's capacity in providing highly skilled professional people.

5. Future Economy

The economy of the basin will continue to expand and prosper within the study period through the year 2020. The region will maintain its position as an important force in both the New England and national economy. It will continue to export valuable services and manufactured goods. It is inevitable, of course, that changes will occur within the various sectors and will influence the growth of the region. Human dynamics especially population, urbanization, employment, personal income, and the nature and composition of the industrial and business economy will be of special importance to the water resources needs and problems of the future. As population, income, and general recreational and economical activity expand, so will the demand for a wider range of public and private uses of water resources.

C. TECHNOLOGICAL CHANGES

1. Improvements to Transportation

The region as well as the nation has undergone dramatic changes in the area of transportation in recent years. An improved highway transportation system has made the population of the region much more mobile and has opened up areas of the basin which were largely undeveloped in the past. The recently constructed highway system with I-95, I-84, I-90, and I-89 crossing the basin have reduced commuting times so that greater areas of the basin are within reach of the urban complexes.

Of the highways mentioned, I-95 and I-90 are presently completed and only a small gap exists in I-84. Interstate-91 is completed in Connecticut and has one ten-mile segment missing in Massachusetts. It is open to traffic in Vermont from the Massachusetts border to White River Junction where it intersects I-89. When the system is totally completed, there will probably be an even greater demand exerted on the recreational and outdoor resources of the Upper Basin. This primary system of highways is supported by a secondary system which varies from excellent in the north to good in the south based on the highway's ability to handle the traffic load pressure.

Coupled with the natural attractiveness of the Connecticut River Basin, the improved or greater accessibility to major population centers explains the current expansion and recreation tourism and vacation industries in the upper basin. A prime example is the accessibility of the Upper Basin for winter recreation-related activity. Even now, while the entire interstate system is incomplete, two or three hours travelling time has already been cut from the commuting time from the southern New England and New York metropolitan area to the upper basin ski slopes.

2. Mechanization and Automation

Changes in technology due to mechanization and automation have brought about significant changes in both the demand for water and the supply of water. On the demand side, there have been increases in irrigation use of water both due to commercial use and domestic use as for lawns and gardens. Water quality in the basin has suffered due to the use of more exotic pesticides for agriculture as well as the increased use of chemicals for industrial use.

Probably the largest changes have been in the increased power demands due to air-conditioning and the increased use of appliances. On the supply side of the ledger, improvements in technology have brought about reductions in the adverse effects of the use of water. Prime examples are recycling of cooling water and industrial process water. Cooling towers for instance which recycle the same water through their cooling system are a tremendous improvement over the traditional once-through type of cooling system which passes river water through the plant and discharges it downstream not to be used again. The use of cooling towers by the Vernon Plant will go a long way towards preventing an increase in river temperatures due to use of the river water for cooling during the summer months.

In the field of water supply, several methods have been used in recent years which will conserve on the amount of water resources available for water supply. A technique that is used right now is that of flood skimming whereby water during the flood freshet periods of the spring is skimmed off and diverted into the water supply system. Normally, this water is carried down the main stem of the stream all the way down to the Long Island Sound and is not available for use by anyone. Flood skimming presents a technique by which this water can be used rather than just discharged to the ocean and wasted.

For the future, there are at least two techniques which hold promise for meeting future water supply needs. One is desalination which is used in arid portions of the world but, as of now, is uneconomical in this section of the country. The second is the technique of cloud seeding or rainfall control to increase precipitation over watershed areas which contribute to water supply reservoirs, thus increasing system yield by 10 to 20%. Research is currently underway by several different agencies and firms to perfect this technique.

In the area of recreation, breakthroughs in pollution abatement will permit greater use of existing resources which are not available today because of poor water quality. An example of this might be the development of offstream swimming pools which might use reconditioned water from streams which are presently of deficient water quality but where it is uneconomical to treat all of the water in the stream.

The great demands that are expected to be exerted in the future on the fish and wildlife resources may result in research into methods of permitting the existing resources to meet greater pressures. This will probably result in improved stocking of fish waters for both resident and anadromous species. There will probably be trends towards management of hunting preserves by private and possibly public interests with an emphasis on providing upland game hunting opportunity. ity.

The one water resource area which is undergoing the most technological change at the current time is that of pollution abatement. Treatment methods yielding higher removal of pollutants than is afforded by secondary treatment methods have been in development stages during the recent years and, therefore, furnish an additional potential to meet future water quality demands. These newer methods termed "advanced waste treatment" consist of methods in a manner not usually practiced. Included in the spectrum of waste treatment methods are those of foam separation, adsorption, electrodialysis, and evaporation as well as older methods such as coagulation, sedimentation, infiltration employed after secondary treatment. These advanced waste treatment methods are capable of removing a wide range of pollutants including nutrients, inorganic salts and non-bio-degradable material. These are described in detail in Appendix D of this report.

For the immediate future it is probably that advanced treatment methods would be applied to secondary treated effluents. Conceivably, however, present conventional processes may be displaced entierly by some form of advanced treatment. In this respect, research is currently in progress to determine the feasibility of going from primary processes directly to advanced processes utilizing physical-chemical methods, thereby omitting the secondary treatment phase and effecting overall cost reductions.

Applications of advanced waste treatment methods have, in the past, been limited. Developments, largely supported by Federal grants, have been stimulated by realistic experiments which have demonstrated new and improved techniques of pollution control. Demonstrations of improved technology currently in progress are aimed at determining from operational-scale examples the effectiveness, reliability and the costs of a number of advanced treatment processes; they serve as practical operational-scale examples to other users. As the problems resulting from pollution continue to grow and the effectiveness of new methods are demonstrated, the broad application by municipalities and industries of those methods which prove successful will become more common.

At present, the cost of advanced treatment processes is relatively high as compared with the cost of secondary treatment. In general terms, estimates indicate that the cost of advanced treatment would be on the order of two times the cost of secondary treatment alone. Future refinement of some methods and technological innovations may effect cost reductions.

For flood control there are no really new improvements in technology although there are approaches which are new at least in their emphasis. These are approaches which concern themselves with non-structural measures such as flood plain zoning, flood proofing, flood warning, evacuation, flood insurance, and in general, land management in flood plain areas. These might be better classified as improvements in concept or changes in concept whereby flood plains can be set aside either by zoning or by acquisition so that they are used not onlyto alleviate flood damages but also to provide land for purposes such as recreation, access to fishing, and open space.

The most significant innovation in New England flood control operations is the recently established Reservoir Control Center at the New England Division, Corps of Engineers offices in Waltham. The center controls the operation of 35 Corps flood control dams, 34 local protection projects and 4 hurricane barriers. The center employs an Automatic Hydrologic Radio Reporting Network which is a computerized network of 41 remote reporting stations and 5 remote recording stations in 5 major New England river basins. Hydrologic data are reported from index locations on important rivers and streams and in tidal streams for the more timely and efficient operation of flood control reservoirs and hurricane barriers. The network, under computer programmed control, will immediately provide read-out information, which is essential for flood regulation, to the Reservoir Control Center at Waltham. The hydrologic network also has the capability of receiving data required for operation of other water resource purposes such as low flow augmentation, recreation, water supply, navigation and fishery enhancement.

3. River Forecast and Warning

There are a number of recent scientific and technological advances which can be expected to have a profound impact on the river forecast and warning service. In some cases, further research and development will be required--in others it is simply a matter of providing the necessary funds to achieve an improved service. The effects on the future service of advanced technology fall into four categories-- data acquisition; forecast methods; meteorological aspects; and data processing, storage and retrieval.

a. Data Acquisition

Data requirements are dependent upon the forecast methods in use which must in turn be geared to forecast requirements. The more advanced hydrologic models require real time observations of river stage (discharge), precipitation, snowpack and frost characteristics, and those meteorological elements influencing snowmelt and evapotranspiration (in lieu of soil moisture)--radiation, air temperture, humidity and wind. Special types of forecasts may require additional observations; e. g., predictions of river ice (formation and breakup) requires knowledge of water temperature and ice characteristics. The development of improved instruments in the future may result in a modest increase in river forecast accuracy, but improved serviceability and reliability of instruments are perhaps potentially more important with respect to most of the elements involved.

Areal averages of precipitation, water equivalent of snowpack, temperature, etc. are required in the preparation of forecasts and obtaining representative point samples of some elements has always presented serious problems. The cost of sufficient samples to provide accurate areal values will likely continue to be prohibitive. The outlook for improvement in forecast accuracy through remote sensing of representative areal averages of several important elements is considered to be very great.

Radar has proven effective for flash flood warnings, but application in a quantitative sense is yet to be achieved. The intensity of radar echo return is largely a function of precipitation intensity, and the time integration of the scope usually yields a reasonably good pattern of storm precipitation. The scope brightness for a given precipitation intensity depends, however, upon a number of other factors as well. It is likely that techniques will be found to minimize these extraneous effects, but automatic integration and digitizing of the radar return taking all these factors into account is not yet a reality. Present and planned research is accordingly directed toward the use of point measurements to adjust the precipitation derived from integrated digital radar data. Three radar (two already in operation and the third scheduled for FY 1971) will each partially cover the Connecticut River Basin. These radars are of the type (WSR-57) which can be modified to produce digitized, integrated signal returns. Even without this modification, the information from these radars will be very helpful in determining the where and when of precipitation.

The record-breaking Midwest floods in the spring of 1969 once again demonstrated the importance of snowpack evaluation in the long-range prediction of snowmelt floods. Under adverse conditions, such as excessive drifting, it is virtually impossible to obtain an accurate estimate of the average water-equivalent of the snowpack over a catchment from point samples. The time and cost of obtaining a large number of observations by traditional snow-tube methods are prohibitive. It now appears that more reliable snowpack evaluation can be made with much less effort by measuring the natural gamma radiation from the soil.

The Weather Bureau is now undertaking research to evaluate natural radiation snowpack measurement techniques. Both airborne and hand-carried sensors are being studied, largely through contract. There is good reason for optimism regarding future applications of these techniques to both river and water supply forecasting.

The possibility of using satellite-borne remote sensing techniques to determine the areal extent and other characteristics of snow cover has been under investigation for a number of years. In the event that future sensors provide a higher degree of resolution than is now possible, the information will certainly be widely used and to good advantage.

In addition to the application cited above, consideration has already been given to the possibility of estimating the surface temperature, depth, water equivalent and albedo of snow, the surface temperautre and ice conditions of lakes and rivers, soil moisture, depth of frost, and expanse of flooding. The Earth Resources Technology Satellites, to be launched by NASA in the next few years will have multi-spectral visual and infrared sensing capability, and it is expected that they will make a major contribution to the applications of satellites in hydrology.

It is evident that advances in remote sensing will not fully supplant the need for conventional reporting networks for many years to come, and it is, therefore, appropriate to consider future development of such networks. The river forecast and warning service has traditionally relied on manual observations and landline communications to collect the necessary reports of precipitation, river stage, etc. The system is obviously outmoded and is being replaced with one that is fully automated as rapidly as the required funds become available.

Many Federal, State, and local agencies as well as utilities and industries have requirements for real-time reports which are common to those of the river forecast and warning service. There are now a number of localized cooperative networks and arrangements for exchange of reports have been made in many cases. It is becoming apparent because of developing technology that fully coordinated networks could better meet the common needs at less total cost.

Any data acquisition system will necessarily require a combination of landline and radio communications. Radio frequencies available for hydrologic data transmissions are "line-of-sight" and the remote areas where radio communications are required are typically of rough terrain. Consequently, scores of land relay stations would be required in New England and most of them would be at sites of difficult access and without commercial power.

The possibility of using a single geo-synchronous satellite for relay of reports certainly merits consideration and successful experiments have been conducted along these lines with the Applications Technology Satellites. The Environmental Science Services Administration and the National Aeronautics & Space Administration are also well along in the design and implementation of the Geostationary Operational Environmental Satellite (GOES) system. The NASA program, responsible for developing the prototype spacecraft, is the Synchronous Meteorological Satellite (SMS) program. In addition to remote sensing functions, the SMS-GOES system will have data collection capability with the spacecraft serving as a relay station. Such a system could become the vehicle for bringing about coordinated reporting networks for water management.

b. Forecast Methods

Models for simulating the hydrologic cycle of a catchment area are rather new in concept but will play an important role in improved forecasts of the future.

Considerable research has been done on the snowmelt process, and it is now possible to make accurate estimates of point snowmelt given all the necessary observations of meteorological and snowpack characteristics. Even so, much research remains to be done in modeling this phase of the cycle for a hetrogeneous natural catchment with the network observations now available. Mountain catchments with large range of elevation, slope and aspect and partially forested present an extremely formidable problem, particularly when precipitation is typically snow at high levels and rain at low levels. Future development in remote sensing may be expected to bring about improved forecasts under these circumstances.

Present forecasts of seasonal or annual water supply volume are based on statistical correlations in which the primary independent variables are monthly precipitation and/or current water equivalent of the snowpack. It is believed that research will soon lead to the development of conceptual models applicable to the forecasting of seasonal volume and its probable time distribution. Similarly, procedures for predicting water temperature and ice conditions in streams will become more scientifically advanced as the requirements increase and the necessary basic data become available.

c. Meteorological Aspects

The input data for hydrologic simulation models are largely observations of meteorological elements such as precipitation, tempreature, humidity, wind and incident radiation. The significance of scientific and technological advances in meteorology which lead to improved quantitative forecasts of these elements cannot be over-emphasized. Flash flood warnings for a community which can be inundated less than an hour after an intense storm must be keyed to a meteorological forecast to be truly effective. Less obvious is the reservoir so located that the controlled outflow must be reduced before the occurrence of heavy rain downstream flooding. A major increase in the accuracy of quantitative precipitation prediction would result in a corresponding improvement in the accuracy and timeliness of river forecasts and warnings and would thereby lead to more efficient water management.

Any realistic hydrologic model must take into account moisture transport from the surface as well as precipitation on the surface and the same can be said of atmospheric models. Hopefully, research on hydrologic models will lead to improved evaluation of evapotranspiration on a real-time basis. If so, such information might serve as input to atmospheric models and result in both improved meteorological and hydrologic forecasts. The development of an atmospheric-hydrospheric model is a feasible goal.

d. Data Processing, Storage and Retrieval

Future developments in the processing, storage, and retrieval of data cannot be viewed solely from the point of view of the river forecast and warning service because of the feedback between forecasts and operations. For optimum benefits from a reservoir, the controlled releases must reflect the anticipated inflow, and the downstream flows cannot be predicted until the scheduled releases from the reservoir have been decided upon. This interplay between forecaster and operator must take place for each point of control in a river basin.

In the highly developed river basins of the future, and taking into account the added significance of water pollution and other elements of control, a unified and computerized approach is rapidly becoming a necessity. We cannot long afford arrangements whereby a multitude of water management agencies (Federal, State, and local) utilities, etc. make operational decisions with no attempt to optimize the overall system. There must be a centralized databank and computer complex (river basin or regional) where hydrometeorological and other relevant data are continually updated as rapidly as possible--where forecasts and operations schedules are made on the basis of "programmed decisions". In other words, all required coordination would be achieved in developing the computer programs and not in reaching operational decisions with each whim of nature.

D. URBANIZATION

The Connecticut River Basin as a whole has experienced a high level of urbanization when compared with the remainder of the nation. In 1963 more than 70% of the total population lived on less than 4% of the land area. This is defined by all places incorporated or unincorporated of 1,000 or more inhabitants. By 1980 this study anticipates that more than 7% of the total basin land area will be urbanized; by the year 2000, 9 1/2%; and by the year 2020, 12 1/2%.

Of the basin urban population in 1960, the majority resided in the Massachusetts and Connecticut portions. Percentages range from about 15% in upper Vermont to almost 80% in Massachusetts and Connecticut. It is expected that most of the future population growth will be absorbed by the urbanization and industrialization of the Hartford-Springfield area which makes up the lower portion of the basin. The outward pressure of the urban growing population will be felt primarily in the suburban fringe areas where land use is certain to become more intensive. Growth will also continue to occur in the flood plain and areas adjacent to them because of the availability of suitable land for development and also because of the easy development due to the already existing social facilities such as schools, hospitals, municipal services, and highways and other accessible modes of transportation.

V NEEDS OF THE FUTURE

A. GENERAL

The purpose of this section is to present those needs and problems which pertain to water resources and related land within the Connecticut River Basin. The study recognizes that since the time of the earliest settlement it has been necessary to develop the natural resources of the basin but not always was it done in the wisest manner. It is recognized that development is natural and desirable but that it should be designed within an orderly pattern to permit solution of today's needs as well as the projected needs of tomorrow without creating problems. An assessment has been made of the problems of today and tomorrow in the Connecticut River Basin and briefly they are as follows:

Problems

- Heavy pollution existing in significant lengths of the basin's streams
- Continuing and enlarging flood damage problem
- Wide variation in regulation of the river's flow
- Barriers to fish passage and navigation
- Growing demand for increased water supply both from within and without the basin
- Over-crowding the basin's public and private recreational facilities
- Inadequate uniform program to preserve existing natural areas which might otherwise be exploited or destroyed
- Lack of a coordinated plan to conserve, develop, and manage the Connecticut's water and related land in an orderly manner.

To determine the need for additional development and management of water resources in the basin, the study addressed itself to a determination of the available supply for each water resource use such as municipal and industrial water supply including power cooling, hydroelectric generation, and outdoor recreation including boating, fishing, swimming, hunting, and aesthetic enjoyment. Concurrently, the present and future demands for each resource use were ascertained by analyzing present and projected population and use trends. The difference between demand and supply was then identified as the need. Both quantity and quality of resource were examined to determine their adequacy to meet identified needs. The study revealed that there is a need to:

- Preserve green space and open space and secure access to them

- Abate pollution and control future pollution

- Prevent thermal pollution from damaging the natural environment

- Reduce flood hazards and lessen flood damages

- Supplement low flows to improve stream conditions

- Increase recreational opportunities

- Provide better environment for fish and wildlife and restore the sea-run fishery

- Preserve inland and tidal wetlands

- Insure adequate water supplies

- Improve multiple-use management of land and water resources

- Expand programs for identifying and maintaining historic sites

- Acquire additional public land

- Insure the adequacy of the future electric power supply

- Improve recreational boating

- Minimize erosion and insure adequate drainage

- Preserve the basin's scenic beauty

Within this section needs are presented in a broad but brief sense. The individual need for each water resource use for each water resource purpose are developed in somewhat more detail in the pertinent appendix dealing with the particular resource or use. The intent here is to present a comprehensive or overall picture of the needs of the basin so that the goals for restoration, enhancement, consumption, preservation, and development of the resources of the basin can be established in an orderly manner.

B. WATER QUALITY

As a participant of this comprehensive study, the Department of the Interior, acting through the Federal Water Quality Administration (FWQA), has inventoried present water quality within the Connecticut River Basin. Pollution loadings have been projected for the future frames of 1980 and 2020, and their effect on water quality has been evaluated.

A basic water quality program to achieve joint State-Federal water quality standards has already been established by the States of Vermont, New Hampshire, Massachusetts, and Connecticut. They have set standards for all interstate streams and coastal waters within the basin which, with some exceptions, have been approved by the Federal Government. Many intrastate streams have also been classified and plans exist to classify all remaining intrastate rivers.

The water quality standards include use designations for each water body, criteria for measuring the quality of the water, and an implementation schedule for the construction of treatment facilities. In general, standards require that wastes receive secondary treatment with disinfection, or the industrial waste equivalent before discharge to a receiving water. Current implementation schedule is completion of necessary treatment facilities by the mid-1970's.

There is a need to provide treatment facilities to handle present and projected waste loadings. Table 5 showed waste loads to basin streams by sub-basin area. The distribution of industrial waste loads by industry for each sub-basin area is shown in Table 15. The 1960 treatment of municipal and industrial wastes was shown by sub-basin area in Table 6.

TABLE 15

DISTRIBUTION OF INDUSTRIAL WASTE LOAD -

BY INDUSTRY

Basin Subdivision	Percent of Industrial Waste Load by Type				
	Paper	Chemicals	Textile	Leather	Other
CRB I	99.0	-	0.5	0.5	-
CRB II	100.0	-	-	-	-
CRB III	31.2	-	36.2	32.4	0.2
CRB IV	66.6	-	33.4	-	-
CRB V	53.4	13.6	14.8	-	18.2[1]
CRB VI	47.0	-	1.8	-	51.2[2]
Basin	78.8	3.6	7.4	2.5	7.7

1. Includes 17.6 percent in food processing industry.

2. Includes 23.0 percent in metal and machinery industry and 27.2 percent in food processing industry.

The estimated capital cost of providing secondary water pollution control facilities sized to meet the 1980 projected waste load is estimated at $171 million with $321 million estimated for the projected 2020 loads. This does not include operation and maintenance costs nor those expenditures necessary for the construction of interceptors, storm sewer separation, pumping stations, and collection systems. A breakdown of the 1980 and 2020 figures by State is shown in the following table. In practice treatment facilities constructed before 1980 will be designed to accommodate 1995 to 2000 projected waste loads to allow for a 20 to 25 year economic life of the plant. This means that total actual expenditures for first operation secondary treatment plants would amount to about $240 M.

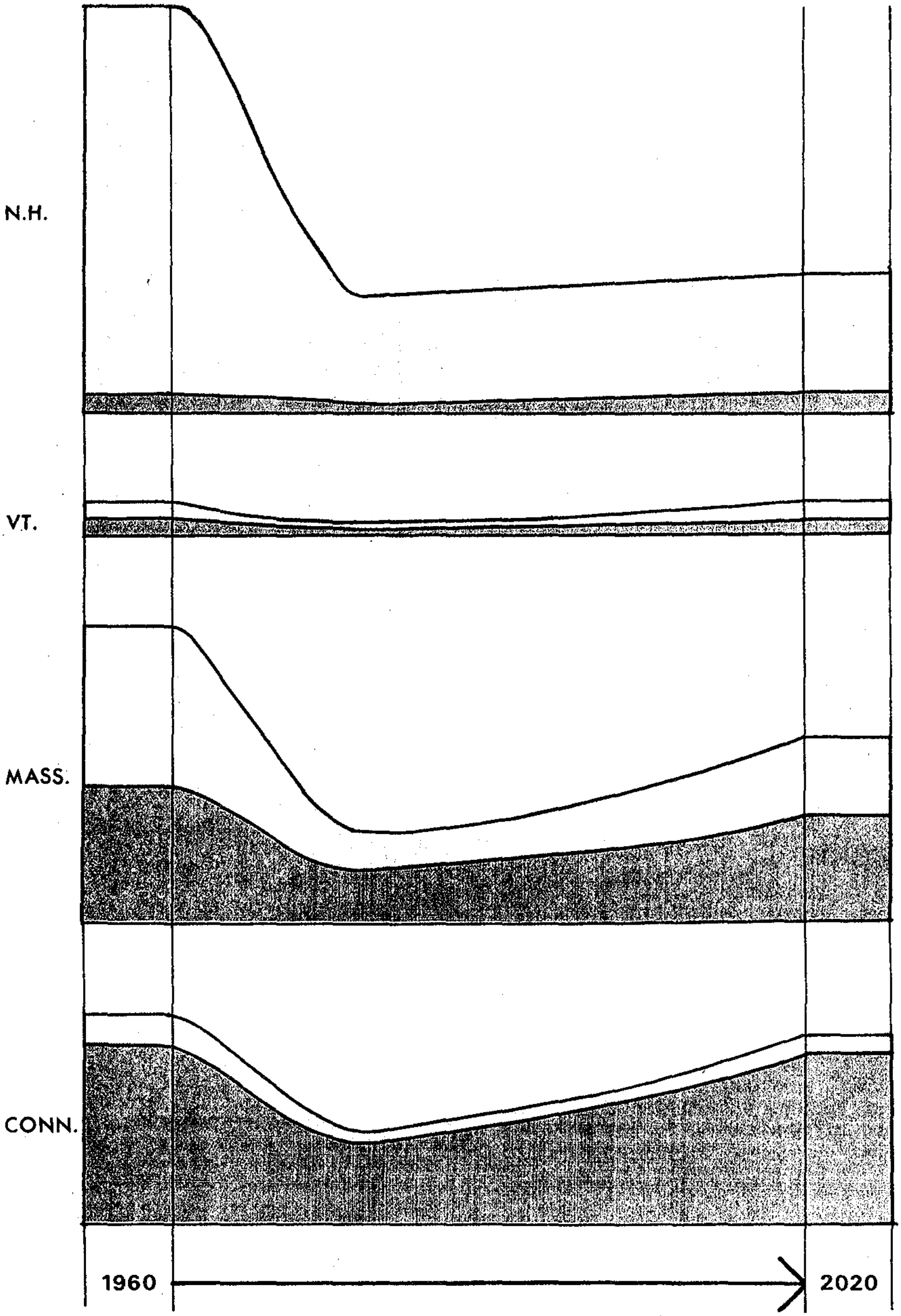
TABLE 16

ESTIMATED COST OF PROVIDING
SECONDARY TREATMENT PLANTS
CONNECTICUT RIVER BASIN

	Cost in Dollars	
STATE	1980	2020
New Hampshire	$30,578,000	$54,893,000
Vermont	20,006,000	49,620,000
Massachusetts	72,031,000	119,974,000
Connecticut	48,600,000	96,268,000
TOTAL	$171,215,000	$320,755,000

Under the increasing pressures of future population and industrial expansion, abatement of pollution and the control of its effects must receive continuing evaluation. Under these pressures, planned facilities will need to be enlarged and controls above basic secondary treatment levels must be considered.

The basin study has estimated that in future years a number of stream reaches will reflect the effect of these pressures and be threatened with a reduction in water quality. These areas are shown in Table 17 and represent areas which, under future growth and critical hydrological and temperature conditions, may be expected to exhibit water quality problems, even after secondary treatment. Water quality classifications in the critical areas shown in Table 17 will be



WASTE LOADING

FIGURE 10

TABLE 17

AREAS OF BASIN WITH DISSOLVED OXYGEN LESS THAN 5.5 mg/l

UNDER LOW FLOW CONDITIONS[1]

River	Reach	Time Frame and Magnitude of Deficienc 1980	2020
Connecticut	Upper Ammonoosuc River to Ammonoosuc River	Major-Moderate	Major-Moderate
	Ammonoosuc River to White River	Minor	Moderate
	Westfield River to Rte. 91 (Conn.)		Minor
Ammonoosuc	Littleton, N.H. to Mouth		Minor
Sugar	Claremont, N.H. to Mouth		Moderate
Black	Ludlow, Vt. to Springfield, Vt.		Moderate
	Springfield, Vt. to Mouth	Moderate	Major
Ashuelot	Keene, N.H. to Mouth	Moderate	Major
Otter	Gardner, Mass. to Mouth	Major	Major
Millers	Winchendon, Mass. to Otter River	Moderate	Major
	Otter River to Orange, Mass.	Moderate	Major
North	Colrain, Mass. to Mouth	Major	Major
Green	Greenfield, Mass. to Mouth	Minor	Moderate
Deerfield	Charlemont, Mass. to Mouth	Moderate	Moderate

TABLE 17 (Continued)

River	Reach	Time Frame and Magnitude of Deficiency 1980	2020
Quaboag	Seven Mile R., Spencer to E. Brookfield R.	Major	Major
	Palmer, Mass. to Mouth	Minor	Moderate
Ware	S. Barre, Mass. to Mouth	Major	Major
Chicopee	Ware River to Indian Orchard, Mass.		Minor
	Indian Orchard, Mass. to Mouth	Moderate	Major
Westfield	Woronoco, Mass. to Little River	Minor	Moderate
	Little R. to West Springfield, Mass.	Minor	Moderate
	W. Springfield, Mass. to Mouth		Moderate
Little	Stevens Dam to Mouth	Major	Major
Farmington	Still River to Pequabuck River	Minor	Moderate
	Pequabuck River to Salmon Brook	Minor	Moderate
	Salmon Brook to Mouth		Moderate
Pequabuck	Plainfield, Conn. to Mouth	Major	Major
Hockanum	Manchester, Conn. to Mouth	Major	Major

1. Based on assumed July temperature and 7-day low flow with 10-year return period.

2. Designation of a deficient reach denotes that deficiency is projected to occur within reach and not that entire reach is deficient.

attained by higher degrees of treatment, by flow augmentation, a combination of these two methods, or by other means.

The basin study recognizes the need for increased measures of pollution abatement which will emerge in future years and that future expenditures will be necessary. These may be due to increased levels of treatment, flow augmentation, modification of industrial plant processes, and other controls or combinations of these.

Adequate water quality depends upon the use for which the water is intended. For some uses such as water supply, needs are stringent and special treatment and control are needed. At the other extreme, uses such as navigation may require lesser quality but are, however, affected by such things as debris, aquatic organisms, clarity, and sediment load. Therefore, the plan must consider the end-use of its particular water quality requirements.

The varied character of the study area, the high demands of a densely populated region, and the heavy pollution loads associated with urban and industrial developments lead to a wide range of water quality needs. These include the need to protect good recreation waters for and from the recreator, the need to provide a healthful and aesthetic aquatic setting, the need to meet expanding water supply demand and the need to adequately treat and dispose large quantities of waste. These diverse demands impose a serious challenge to the sound management and use of water.

The hydrological conditions which create low flow conditions deleteriously affect the water quality by:

- Reducing the reaeration capacity of the stream due to a reduction in turbulence at the air-water interface.

- Increasing the concentration of introduced pollutants. For those pollutants which are subject to biological degradation, such increases in concentrations similarly concentrate the demands on the oxygen resources of the river.

- Decreasing the velocity and increasing the time during which a pollutant remains in the same reach of the river. Such retardation, in effect, concentrates the oxygen demands of a waste within short reaches.

- Decreasing the velocity which results in a greater amount of suspended matter being allowed to settle on the bottom. Such deposits may be resuspended to introduce a concentrated slug of pollutants to downstream areas or may create local water quality problems from floating sludge or the creation of a bottom devoid of oxygen.

- Elevating water temperature. Increases in temperature during low flow periods occur because of the reduced quantity of water, a decrease in surface area thereby decreasing atmospheric cooling, and reduced velocities which increase the time during which warming can occur. Such temperature rises increase the rate of biological activity thereby concentrating the demands on the oxygen resource.

In addition to the seasonal variations which exist, daily and hourly fluctuations in flow along the main stem and a number of tributaries occur due to the operation of many industrial and hydroelectric impoundments.

The flow in the Connecticut River is regulated at 15 major impoundments on the main stem and by dams on many of the tributaries. Except for impoundments near the headwaters of the Connecticut River, which provide seasonal storage of water, the impoundments are operated to provide:

(1) peak power generation capacity or,

(2) industrial water supply and power generation.

The tributary Westfield, Chicopee, Deerfield, Farmington, and other rivers are similarly regulated.

The present quality of significant portions of the Connecticut Basin precludes or impairs the use of the basin's waters for many legitimate purposes including recreation, fish and wildlife habitat, public water supply, and aesthetic enjoyment. On the main stem Connecticut River, the water quality below the Upper Ammonoosuc River and again in the vicinity of Springfield, Massachusetts is degraded for a combined distance of 70 miles. Water quality on portions of some tributaries, the Ashuelot, Mascoma, Sugar, Black, Millers, Chicopee, Deerfield, Hockanum, and Farmington Rivers and other smaller streams is similarly degraded.

Except for the upper reaches of the Connecticut River and headwaters of its major tributaries, swimming is generally not allowed by public authorities because of high bacterial concentrations. Boating, fishing, and sailing to some degree occur throughout much of the basin. Boating and fishing activity, however, is severely curtailed in the polluted areas of the basin due to aesthetic considerations or an impaired fishery resource.

From the Connecticut River's headwaters to the Upper Ammonoosuc River, the main stem is free of major sources of organic pollution although untreated municipal wastes from a few smaller communities result in increases in the coliform level.

Pulp and paper wastes enter the Connecticut at the Upper Ammonoosuc River. The introduction of these wastes, presently approximates 150,000 pounds/day of BOD_5 and results in severe depletion of the dissolved oxygen as far downstream as the Moore Dam.

Below the Moore Dam, recovery of the Connecticut begins and dissolved oxygen levels increase to levels higher than 5 mg/l. Limited data indicates that much of the wastes introduced into upstream areas may settle out in the relatively quiescent water of the Moore Reservoir. The Connecticut River, from the vicinity of the Passumpsic River downstream to Holyoke, Massachusetts is of a relatively good quality except for moderately high levels of coliform.

At Holyoke, Massachusetts gradual deterioration of the water quality occurs and is reinforced by significant quantities of waste introduced in the vicinity of Springfield, Massachusetts. Reductions in the dissolved oxygen to levels of 2 - 3 mg/l occur and gross bacteria concentrations are present. High concentrations of the nutrients, nitrogen and phosphate, exist as well as significant algae counts.

Below the Enfield Dam, just downstream of Springfield, the Connecticut becomes an estuarine water body. Although not affected by salt water throughout, tidal action is felt to a point just upstream of Hartford, Connecticut. Water quality in the estuarine waters is presently impaired to a moderate degree. Dissolved oxygen concentrations range close to 5 mg/l, the presence of coliform bacteria in sufficiently high numbers precludes water contact sports or bivalve shellfisheries, and concentrations of nutrients are sufficiently high to foster algae blooms.

Although stream waters of the basin are rarely used for municipal water supply, the present water quality presents a barrier to the economical development of such waters for additional supplies.

The major waters of the Connecticut River Basin were analyzed to determine the quality which would exist under a seven-day low flow with a ten-year return period, after all wastes had received a minimum treatment program of 85% removal of biochemical oxygen demand. This flow was selected because this criteria is utilized in the interpretation of State water quality standards. Under these assumptions, certain reaches of the basin waters do not meet the assumed dissolved oxygen objective of 5.5 mg/l. A detailed list of these areas of the basin is shown in Table 17. Based on these data, it is apparent that measures in addition to secondary treatment will be required to maintain adequate water quality in some parts of the basin under assumed future conditions. Further, from a comparison of the present water quality, it may be generalized that areas which do not meet the dissolved oxygen objectives are areas which are presently severely degraded.

The range of dissolved oxygen projected under the assumed conditions has been generalized to three categories for purposes of discussion:

- Those less than 3 mg/l have been termed "major".

- Those between 3 and 5 mg/l, "moderate".

- Those between 5 and 5.5, "minor".

By 1980 reaches of the Upper Connecticut River and Otter, North, Quaboag, Ware, Little, Pequabuck, and Hockanum Rivers are projected to have major deficiencies in the dissolved oxygen level under critical conditions. Moderate deficiencies in 1980 are projected for reaches of the Black, Ashuelot, Millers, Deerfield, and Chicopee Rivers. Minor deficiencies by 1980 are projected to occur on the Green, Westfield, and Farmington Rivers.

By 2020 deficiencies are projected to increase in magnitude in reaches of those rivers noted above. In addition, minor deficiencies are projected to emerge on the Ammonoosuc River, while moderate deficiencies are projected for the Sugar River.

The estuary waters are projected to attain a relatively high dissolved oxygen level throughout the period of study. Even under conditions expected to occur during the critical period dissolved oxygen levels are projected to approximate 6 mg/l.

The capacities of secondary basin streams to assimilate wastes were estimated assuming that the dissolved oxygen concentration of 5.5 mg/l was a minimum objective. Critical combinations of flow and temperature were analyzed as was a conservative estimate of the self-purification capacity of the stream.

C. POWER

1. General

Within the Connecticut River Basin, power requirements are currently met by a group of utilities whose operations are coordinated on a regional basis to meet a common need. The New England region is served by an interconnected system, and power is exchanged between utilities to provide maximum economy and reliability. About 90% of the total energy required for New England is provided directly to consumers by privately-owned systems, many of which purchase a substantial amount of power from the private sector.

Until recently, the basin has been exporting peaking power, providing large blocks of power from the hydroelectric plants at Moore and Comerford to markets as far south as Boston. In 1967 energy needs of the basin were approximately 10 billion kilowatt hours or about 25% of the New England total with a peak demand in the order of 2.6 million kilowatts. Now that its own energy demand has increased, the basin currently consumes essentially what it produces although it still exports peaking power. In future years, the basin will have to import energy both baseload and peaking in contrast to its historical export role.

Assuming the same rate of growth as the New England power market, basin energy requirements may be expected to climb to 23 billion and 200 billion kilowatt hours in 1980 and 2020, respectively with corresponding peaks in the order of 5 million kilowatts and 40 million kilowatts, respectively. It is estimated that basin demands in 2020 will be far more than the basin's available economic supply.

The electric power resources of the Connecticut River Basin are dedicated to assist in serving the load of all New England. Because of the make-up of the power market area of New England with its interconnections and power interchanges, the Connecticut River Basin power demand is not usually and should not be treated as a separate entity.

The basin exports peaking power from its hydroelectric installations and will continue to do so. However, the basin will be depending more and more on baseload energy generated outside of the watershed. Accordingly, the following table shows the estimated total power requirements for the entire market area together with that portion of the supply which is estimated to be provided by the resources of the Connecticut River Basin. Figure 11 illustrates the projected allocation of power supply to the Connecticut River Basin.

TABLE 18

ESTIMATED TOTAL POWER REQUIREMENTS FOR THE NEW ENGLAND MARKET AREA (megawatts)

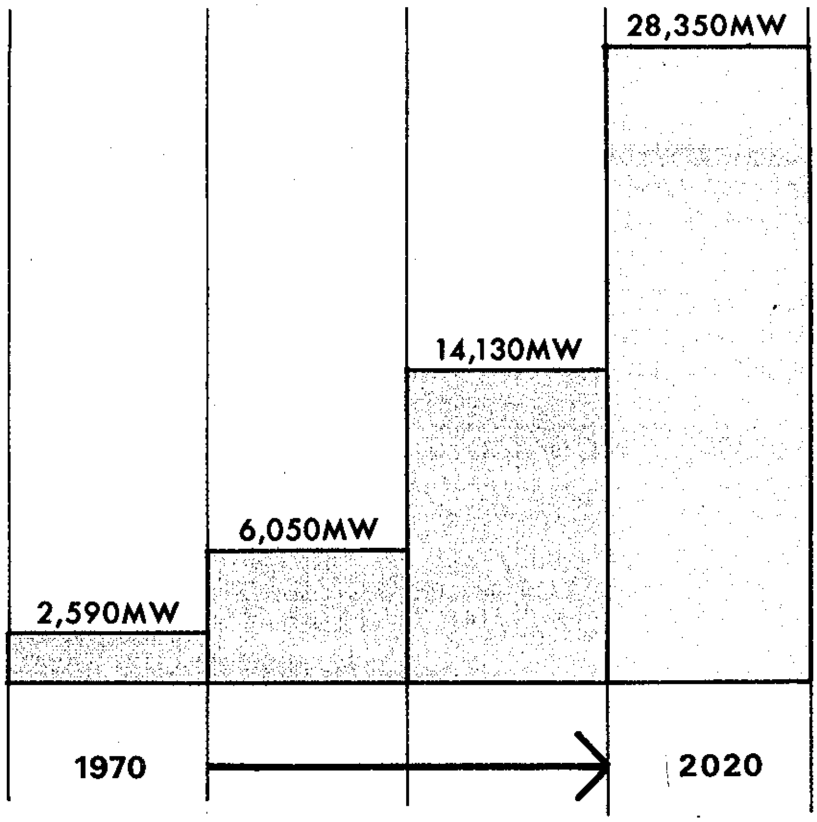
Required	1967	1980	2000	2020
Generation	10,288	27,825	92,825	232,825

ASSUMED ALLOCATION OF POWER SUPPLY TO THE CONNECTICUT RIVER BASIN

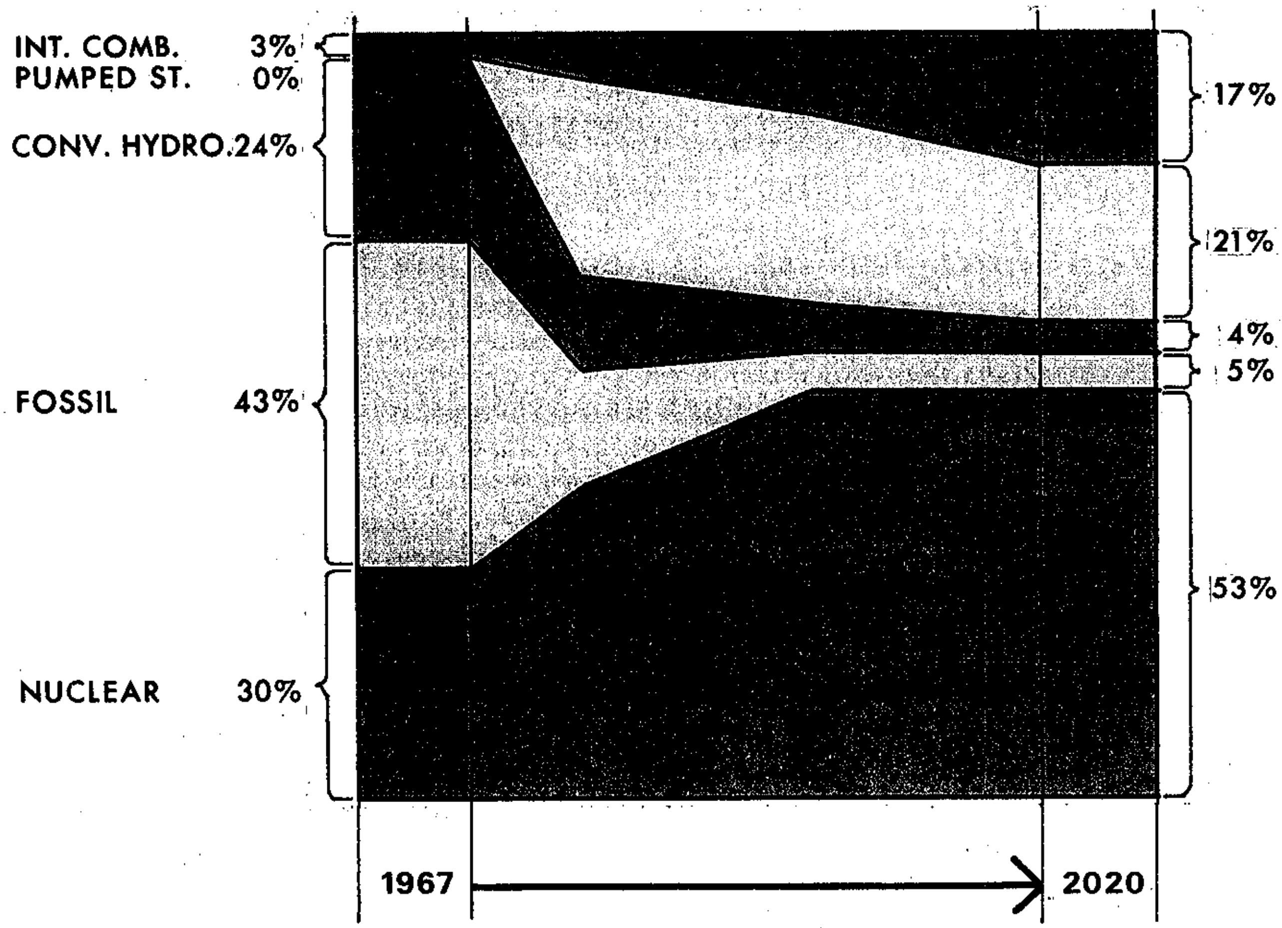
	1967	1980	2000	2020
Conventional hydro	621	709	859	1,009
Pumped storage	-	1600	3600	5,900
IC/GT	80	338	1500	5,000
Fossil steam	1103	901	674	1,435
Nuclear steam	785	2498	7500	15,000
TOTAL	2,589	6046	14,133	28,344
Total as % of market	25.2	21.7	15.2	12.2

In the past, the power required for the more or less constant baseload was provided by fossil steam fuel plants while intermittent surges or peak demands were met by operation of conventional run-of-the-river hydroelectric plants. Due to the recent changes in technology, it is expected that nuclear power steam plants will replace the traditional function of fossil-fuel plants and pumped storage hydroelectric installations will supplant the run-of-the-river hydroelectric plants. This shift in composition of the power system is evidenced in Table 18 and graphically illustrated in Figure 12.

Table 18 indicates that by the year 2020 the Connecticut River Basin will increase its power supply to 11 times its 1967 capability. The table also shows that conventional hydro will decline from its



POWER SUPPLY WITHIN BASIN FIGURE 11



COMPOSITION FUTURE POWER SUPPLY FIGURE 12 present role of about 24% of the total power to 4% in the year 2020 while pumped storage will increase from 0% at present to 21%. Fossil-fuel steam plants which currently provide base generation capability will decline from 43% of the total power capacity to 5% in the year 2020. During the same period, nuclear fuel plants will increase from 30% of the system capacity at present to 53%.

In meeting the needs for future power there will be many obstacles to overcome. All major types of power plants - conventional hydro, pumped storage, fossil-fuel, or nuclear - are large users of land and water. Both fossil and nuclear require extensive facilities to dissipate heat, and fossil plants may also foster air pollution problems. The environmental or siting problems will be among the most difficult facing the industry and the pressure to resolve them will be even more critical in future years. Careful planning during site selection is necessary to avoid aesthetic and ecological problems. Unless technological advances occur to eliminate or minimize adverse effects onthe environment, all future installations whether nuclear, fossil-fuel, conventional hydro, and pumped storage will require careful design controls.

2. Comparison of Problems Affecting Different Forms of Energy

a. Hydroelectric Plants

Hydroelectric power stations offer many advantages over fossil and internal combustion power plants. Chief assets are:

- lower operation and maintenance costs
- no contribution to air pollution
- adaptability to remote control, automatic operation and use for spinning reserve
- long life
- low charges of depreciation
- high reliability
- low rates of outages.

There are also additional secondary benefits such as the possibility of combining hydroelectric power with other uses such as recreation, water supply, and flood control within the project reservoir. Conversely, there are varied environmental restrictions imposed on potential hydroelectric developments. Diurnal fluctuations in water releases impose burdens on downstream riparian users by affecting flows. Impoundments will change the ecological balance of the inundated stretch of river. This may cause the aesthetic quality of a river reach to be impaired and valuable land resources may be lost. These conditions must be constantly re-examined and evaluated to insure that they are recognized in developing the hydroelectric resources of the basin.

b. Pumped Storage Plants

The pumped storage plant includes a pumping generating unit operating between an upper and lower storage pool. It generates energy during system peak load periods by release of water through the units from the headwater pool. During off-peak load periods, energy from some other source is used to pump water from the lower pool back into the headwater pool. In this way the system operates as a more or less closed unit, passing essentially the same water back and forth from the upper to the lower pool. While this arrangement consumes more energy than it produces, its economic advantage comes from converting low value off-peak energy to high value on-peak energy. A further advantage of pumped storage hydro is the elimination of on-stream surges which upset river flow regulation during peak operations of a conventional hydroelectric project.

Essential to the construction of a pumped storage project is the availability of pumping energy at low cost. With the large thermal generating plants which are being constructed in and near the Connecticut River Basin, off-peak pumping energy will be readily available. Another advantage of pumped storage plants is the ability to combine them with existing reservoirs, using the existing reservoirs as the lower pool and adding an upper reservoir at a convenient location which has a high head differential.

c. Thermal Electric Generation

The largest industrial demand on the water resources of the basin is that of thermal electric generation. Steam plants withdraw more water than any other industrial facilities. Nearly all of the withdrawls are for condensing the steam used to produce electric energy. The cooling water circulates through the power condensers and absorbs enough of the heat retained by the steam after it leaves the turbine to condense it for return to the feed water heaters and boilers. The heated cooling water is returned to a stream where consumptive losses are relatively small, although the heated water contributes to thermal effects through the reduction of the water's capacity to hold dissolved oxygen. The reduction of the capacity to hold dissolved oxygen reduces the steam's ability to assimilate waste loads and may cause adverse effects on aquatic life. Thermal plants, therefore, require that they either be located close to a source of large quantities of water for cooling or that they use expensive cooling towers.

The present lack of thermal plants above the Massachusetts border is not due to the shortage of either sites or water but rather to the demands imposed by load centers and the present adequacy of installed hydro capacity. As the region continues to grow, new electric generating pltnts will be required over a greater length of the river. As this divergency takes place, once-through cooling will become impractical when the heat assimilative capacity of the stream is reached or the water demands exceed the available supplies. At that time future thermal electric plants will have to be limited to the tidal sections of the river and to the main portions of those hydroelectric station ponds where circulating water systems could be used. Further demands for future generation could be attained by the use of cooling towers and combination thereof with cooling ponds.

D. RECREATION

1. Basic Assumptions

The analyses used in the development of recreational participation estimates in the Connecticut River Basin are based on the following four assumptions:

- That the Northeast Regional participation rates from Outdoor Recreational Resources Review Commission Study Report Number 19[1] are valid for determination of participation in the outdoor recreation activities for the five States in the Connecticut River Basin Market Area.

(1) Reference Appendix H.

TABLE 19

Estimates of Unsatisfied Recreation Participation by Activity for 1960, 1980, 2000, and 2020, Connecticut River Basin

Sub-basin	Activity	Unsatisfied Recreation Participation in Activity Days per Summer Season 1960 (000)	1980 (000)	2000 (000)	2020 (000)
I	Camp	228	939	2,342	4,515
	Picnic	136	201	313	585
	Swim	393	1,220	2,798	5,337
	Boat 1/	--	59	229	508
	Boat 2/	--	182	539	1,115
II	Camp	145	677	1,556	2,776
	Picnic	111	180	313	544
	Swim	329	981	2,061	3,599
	Boat	--	30	132	283
	Boat	--	123	347	669
III	Camp	965	3,324	7,833	15,099
	Picnic	378	738	1,231	1,953
	Swim	1,623	4,528	9,807	18,118
	Boat	--	246	801	1,720
	Boat	--	684	1,852	3,749
IV	Camp	486	1,764	3,974	7,143
	Picnic	428	725	1,204	1,847
	Swim	696	2,501	5,294	9,240
	Boat	77	281	605	1,053
	Boat	128	499	1,128	2,006
V	Camp	847	2,294	5,115	9,650
	Picnic	2,277	4,501	7,486	11,153
	Swim	602	6,425	13,244	22,912
	Boat	157	543	1,082	1,799
	Boat	564	1,337	2,490	4,000
VI	Camp	691	2,419	5,414	9,962
	Picnic	1,345	2,774	4,769	7,073
	Swim	1,817	7,192	14,136	22,999
	Boat	184	553	1,060	1,665
	Boat	202	931	1,892	3,051

1/ Unrestricted boating, characteristic of water surface areas of 500 acres or more.
2/ Restricted boating, characteristic of water surface areas of less than 500 acres.

TABLE 20

RECREATION PARTICIPATION AND SUPPLY RELATIONSHIPS
EXPRESSED IN TERMS OF ACRES OF LAND AND WATER
CONNECTICUT RIVER BASIN

Sub-basin	Unsatisfied Water-Oriented Recreation Days	Land	Water	Unsatisfied Water-Oriented Recreation Days	Land	Water	Unsatisfied Water-Oriented Recreation Days	Land	Water
	(000)	(acres)	(acres)						
I	-- 1/	--	--	426	3,550	1,540	3,626	30,200	13,030
	--	--	--	1,295	10,800	1,540	7,962	66,350	9,530
II	--	--	--	210	1,150	740	2,024	11,250	7,260
	--	--	--	876	4,850	1,050	4,777	26,550	5,720
III	--	--	--	1,754	7,300	6,310	12,287	51,200	44,100
	--	--	--	4,884	20,350	5,850	26,777	111,550	32,040
IV	554	3,080	9,940	2,009	11,150	7,210	7,525	41,800	27,030
	912	5,070	5,460	3,570	19,850	4,270	14,332	79,600	17,150
V	1,118	4,660	20,060	3,878	16,150	13,920	12,846	53,500	46,130
	4,031	16,800	24,120	9,551	39,800	11,430	28,566	119,000	34,180
VI	1,317	5,480	23,640	3,951	16,450	14,180	11,897	49,550	42,720
	1,444	6,020	8,640	6,653	27,700	7,960	21,795	90,800	26,080

1/ Within each sub-basin first data row relates to estimates based on demand-supply relationships for unrestricted boating; the second row relates to estimates for restricted boating.

- Regional projection factors affecting income and education are valid indices for projections of recreation participation.

- Water quality standards established under the Water Quality Act of 1965 will be successfully met.

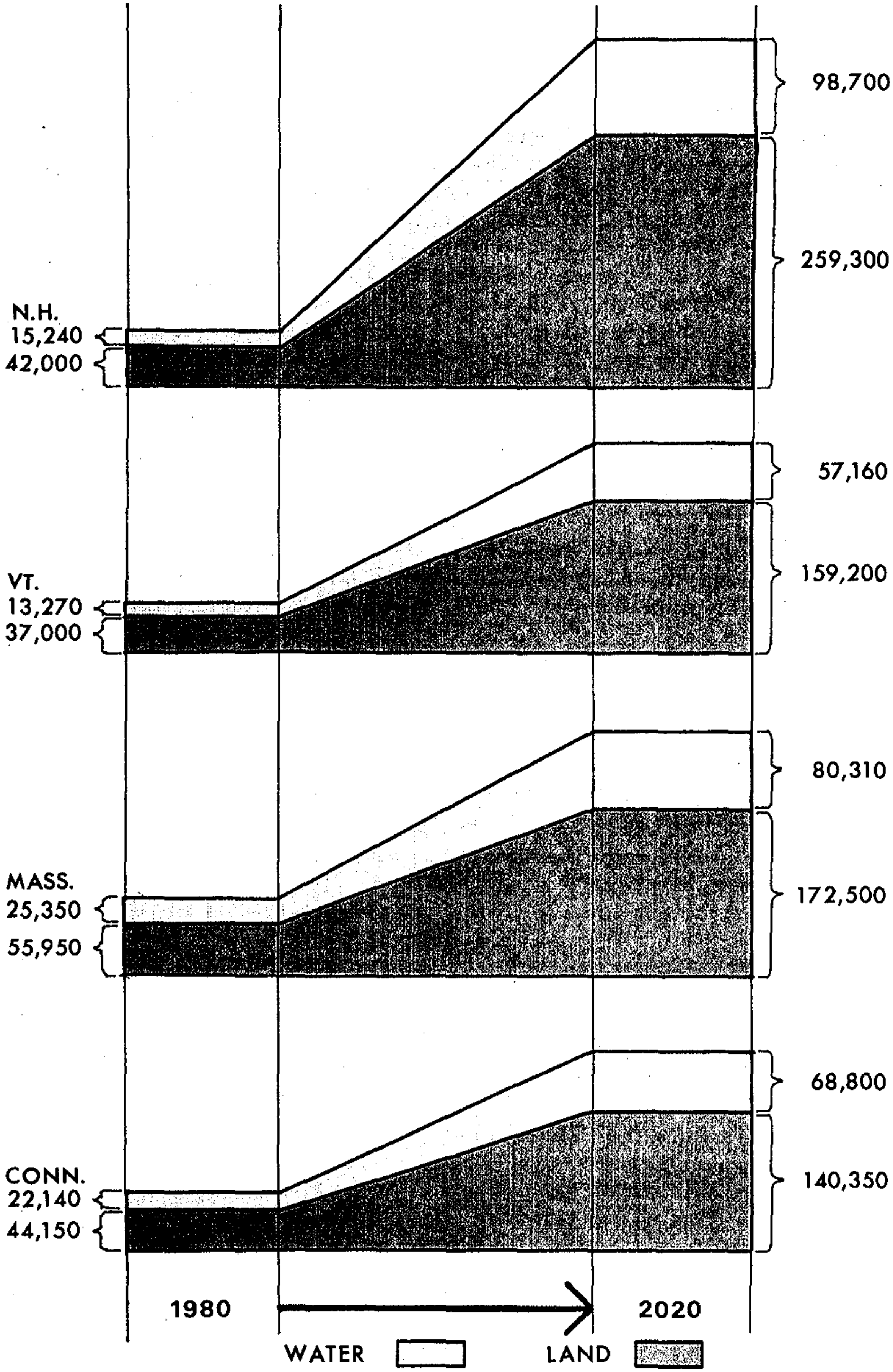
- No major wars, depressions, or other major catastrophies will occur that will subsequently alter the projected population and economic growth anticipated.

The estimates of outdoor recreation participation for the Connecticut River Basin are based on present day-use participation in selected activities and the interpretation of recreation day-use patterns and habits for weekend, overnight, and vacation recreators. Participation estimates were made for the years 1960, 1980, 2000 and 2020 in four recreation activities: swimming, boating, picnicking, and camping.

Estimates of supply are based on the Bureau of Outdoor Recreation's 1965 nation-wide inventory, updated with information from state-wide Comprehensive Outdoor Recreation Plans as well as the Bureau's Land and Water Conservation Fund Programs.

The 1965 inventory used as the 1960 supply in this report has been updated and projected to the year 1980. The 2000 and 2020 supply estimates are based on the 1980 estimates adjusted for expected shifts in recreation use conditions. A comparison of demand and supply reveals certain surplus and deficit conditions so that recreation demand and supply figures may be translated into real physical terms. Standards have been applied to convert the unsatisfied demand estimates into recreation days and then to acres of land and water required to contend with the unsatisfied demand. Estimates of unsatisfied demand are presented in Table 19 for the six sub-basins of the Connecticut River Basin. The unsatisfied demand and water-oriented recreation days and the estimates of associated resource dimensions are provided in Table 20 and illustrated in Figure 13.

Land and water requirements to meet the unsatisfied demand were delineated into two categories for planning analysis: unrestricted boating, characteristic of water surface areas of 500 acres or greater; and restricted boating, characteristic of water surface areas of less than 500 acres. A complete discussion of the breakdown is presented in Appendix H.



UNSATISFIED DEMAND FOR RECREATION (IN ACRES)

FIGURE 13

The outdoor recreation resources of the Connecticut River Basin are presently an outstanding attraction of national significance. The objective of the recreation needs study was to analyze the existing and latent demand for outdoor recreation and resources and to evaluate the capability of the supply. Estimates of recreation needs have resulted from the comparison of the two and so that these estimates may be comprehended in real physical terms, standards have been applied to convert them into acres of water. These estimates are not absolute rather they represent planning-aid data for the purpose of this report. The study took into account the socio-economic and environmental characteristics of the Connecticut River Basin so as to satisfy the needs of the growing population while still maintaining the high quality of the present outdoor recreation opportunity.

2. New Hampshire

The Connecticut Lakes area of New Hampshire, an unusually scenic area, contains an abundance of water surface areas which are largely undeveloped. There is a need to maintain this area in its present scenic wilderness state to meet the demand for more primitive recreation pursuits.

According to the study criteria presented in Appendix H, there is no need for additional water bodies in the northern portion of New Hampshire if the existing supply were developed properly. Based on present development of water bodies, there is a need for an additional 1,540 acres of unrestricted boating surface and 1,540 acres of restricted boating surface. However, through improved public access and provisions of recreation facilities at existing water bodies, 2400 additional acres of unrestricted boating and 200 acres of restricted boating can be provided.

In the lower portion of New Hampshire, studies indicate that there is a need for 6,300 acres of unrestricted boating surface and 5,800 acres of restricted. Improvement to existing water bodies will not add appreciably to present supply.

In essence then, the northern portion of New Hampshire with improvement of existing bodies shows slight deficit of recreational surface while the southern portion of the State shows a much larger deficit. This is indicated on the following table.

TABLE 21A

1980 Water Surface Needs in New Hampshire

CRB I

	Boating Unrestricted	Boating Restricted
Needs	1,500 acres	1,500 acres
Improvement of existing	2,400	200
Net	+ 900 acres	-1,300 acres

CRB III

	Boating Unrestricted	Boating Restricted
Needs	6,300 acres	5,800 acres
Improvement of existing	-	-
Net	-6,300 acres	-5,800 acres

3. Vermont

Within the State of Vermont, the water surface needs are 13,270 acres by 1980; 31,490 acres by 2000; and 57,160 acres by 2020. Land requirements are 37,000 acres by 1980; 87,800 by the year 2000; and 159,200 acres by the year 2020. There is a greater potential use for water-oriented recreation in Upper Vermont than in Upper New Hampshire. Existing water bodies such as Moore, Comerford, and Wilder Power Reservoirs can supply large areas of water to meet future needs; however, at the present time the water quality of Moore and Comerford is not adequate for recreational use and may not be available for considerable time to come. In the lower part of Vermont, however, there is an acute shortage of available surface water for recreation. Improvement to existing water bodies will not be sufficient to satisfy the 1980 needs. It will be necessary for the people of lower Vermont to look to northern Vermont for the recreational surface to meet their needs.

Considered as a whole, the surplus in the northern part of the basin, both by improving recreational facilities and development of new facilities, is adequate to meet the need exerted in the northern and southern portions of the basin. The 1980 needs for recreational water surface in Vermont, after development of existing water bodies, is shown in the following table.

TABLE 21B

1980 Water Surface Needs in Vermont

CRB II

	Boating Unrestricted	Boating Restricted
Needs	740 acres	1,050 acres
Improvement of existing	-	-
Net	-740 acres	-1,050 acres

CRB IV

	Boating Unrestricted	Boating Restricted
Needs	7,210 acres	4,270 acres
Improvement of existing	700	-
Net	-6,510	-4,270

4. Massachusetts

In the State of Massachusetts the 1980 water surface needs are 25,350 acres which would be expected to grow to 49,020 by 2000 and 80,290 acres by the year 2020. The associated land requirements are estimated to be 55,950 acres by 1980; 106,300 by the year 2000; and 172,500 by the year 2020. Improved public access and development of additional recreation facilities in the existing water supply reservoirs would make available over 12,000 acres of water surface. This is apparent in the following table:

TABLE 21C

1980 Water Surface Needs in Massachusetts

CRB V

	Boating Unrestricted	Boating Restricted
Needs	13,920 acres	11,430 acres
Improvement to existing	13,000(1)	900(2)
Net	920 acres	10,530 acres

(1) Includes 12,000 acres in water supply reservoirs.
(2) Includes 260 acres in water supply reservoirs.

However, the State rules and regulations, approved by the State Department of Public Health and State laws, must be amended before contact recreation such as swimming within a water supply reservoir can be allowed. A discussion of this subject is contained in Appendix R. Without complete use of water supply reservoirs for recreation, there is no chance for meeting the needs for boating that will be exerted on CRB V by 1980. In fact, even with the use of water supply reservoirs, there will still be a considerable deficit in the restricted boating.

5. Connecticut

In the State of Connecticut there will be a need for 22,140 acres of water surface additional by the year 1980; 33,350 by 2000; and 68,800 by the year 2020. The associated land requirements to be 44,150 acres by the year 1980; 87,850 acres by 2000; and 140,350 acres by the year 2020.

As the figures in Table 20 show, the shortage of water-oriented recreational facilities in CRB VI is severe. Again, a substantial portion of this need could be met by improvement to and use of existing water supply reservoirs. The following table illustrates the impact of using water supply reservoirs for recreation.

TABLE 21D

1980 Water Surface Needs in Connecticut

CRB VI

	Boating Unrestricted	Boating Restricted
Needs	14,180 acres	7,960 acres
Improvement of existing	1,300(1)	-
Net	-12,880	-7,960

(1) Almost entirely in water supply reservoirs.

Probably the greatest source of recreational water surface will be the main stem of the Connecticut River through the Hartford to Holyoke Recreational Navigational Project and by development of facilities at the Bureau of Outdoor Recreation's Gateway Unit.

As large as the water surface requirements appear to be, the land requirements are far greater. In the lower portion of the basin, in CRB Areas V and VI, due to the rapidly increasing urbanization, there is a need to provide adequate open space for present and future use. In the northern portion of the basin CRB Areas I, II, III, and IV, although the pressures of urbanization are not as great, there is still a need to preserve the unique environmental quality that presently exists. Although the pressures exerted by the population are not as great, they still exist to the extent that they will, if unchecked, change the beauty of the basin. One way to preserve the beauty of the valley is to acquire the land adjoining our streams and natural water bodies so that they will be available for the use of future generations.

Finally, due to the tremendous pressures for additional water surface area, and the great impact that use of water supply reservoirs could provide in meeting this need, there is a need to study the possibilities of making contact recreational use compatible with water supply reservoirs. At present there is limited information available in New England on the cost of providing facilities at water supply reservoirs or the certainty that proper maintenance can be performed to present any likelihood of health problems.

E. ENVIRONMENTAL PRESERVATION

The character of the Connecticut River Valley varies from forest to urban centers, from ski mountains and rolling hills to coastal marshes. In remote corners where man has not been a dominant element, bare wilderness conditions remain. In populated areas, intensity of land use and water management can and has been changed.

The Connecticut River Valley has little true wilderness and yet nature's element has not been completely removed. The environmental quality and character of the Connecticut River Basin is a nationally known attraction and its unique quality is not found in any other section of the country. Increasing pressures or urbanization, improved highways, and the need for additional outdoor recreational opportunity are gradually diminishing this natural resource. Consequently, there is a need to take coordinated action to retain the present environmental quality of the Connecticut River Valley. There is need for a coordinated program of action at Federal, State, and local levels to insure that this can be accomplished.

Adequate land use controls and river areas are of major concern. Throughout its linear course, the rivers, land form, land use, and political character changes frequently. It is, therefore, mandatory that the State or, where necessary, interstate agencies act in an effective manner to safeguard the environmental amenities inherent in various reaches in the Connecticut River Basin. This cannot be done by planning alone. Laws must be established and funds appropriated. Scenic river programs must be conceived and effected.

The program must accomplish two things: first, it must restore, protect, and enhance cultural, scenic, and public health aspects of a river valley; and second, it should provide public access for controlled recreation activity. To do this, adequate land use control measures must be established; and they must be, to be most effective, a cooperative program between State and local government.

There is a need to protect our existing land. As noted earlier, the natural forces and the activities of man described in Appendix O of this report have resulted in an exceptionally scenic landscape. On a varied and attractive form, man has created a pattern of towns, fields, and forests which has great variety and visual appeal. In many instances, urbanization and industrialization have been cruelly destructive of both natural features and the physical remains of man's past; yet the Connecticut River Basin remains one of the nation's most attractive regions. As the population continues to grow and the northeastern megalopolis becomes more consolidated, there will be an increasing need to protect our existing natural areas and historical resources. Only by the most exerted governmental effort, local, State, and Federal, and the most determined commitment by the people of the valley, can our heritage be preserved.

There is a need to do the following:

- Areas of significant natural, historical, and archeological importance should be identified, designated by the government at local and State levels.

- When historic sites are selected for preservation, increased attention should be given to the setting which so often contributes to their effectiveness such as Plymouth, Vermont where the virtually unchanged village adds much to the effectiveness of the Coolidge Home.

- There is a need to evaluate the historical and archeological resources described in Appendix O as to their possible inclusion in the registry of national historic landmarks as well as to identify, for inclusion in the registry, any additional sites of State and local significance

- There should be an evaluation of the natural and scientific resources described in Appendix O to determine the sites of national, geologic, ecologic, or scientific importance, if any, for possible inclusion in the registry of natural or environmental landmarks.

- Finally, steps should be taken to insure that, prior to development of any extensive areas, investigations be undertaken to determine the natural, historic, or archeological importance of the site and to insure that where there is significant value, it will not be disturbed or, in lieu of that, to take necessary steps to mitigate losses.

Generally, there is a need to preserve the overall scenic quality of the basin by sound land-use planning and effective zoning to prevent the scenic quality from being damaged or destroyed. The following are a few additional problems on environmental preservation.

In order to provide a quality setting for outdoor recreation in the basin, a vigorous program for conservation and restoration of major natural resources and scenic elements is needed. Natural resources planning should include programs to preserve the ecological environmental conditions to make possible the use and enjoyment of these resources for recreation. Where changes occur that reduce the recreation value of land and water, steps must be devised to counteract the ill effects. Changes in land management and types of vegetation can affect such factors as moisture content, transpiration, evaporation, salinity, and the level of the water table. These are items that affect the plant and animal life of the land for recreation and also have an effect on the aquatic population of our streams.

Although this is not truly a water resource area, there is a need to eliminate the pollutants which are invading our atmosphere such as from burning dumps and from an occasional industry. The value of clean air to the valley, to a recreation-minded State, can hardly be exaggerated.

The unbroken stretches of mountain ridges are greatly appreciated recreation resources. There must be controls to prevent developments such as ski resorts, roads, power lines, and the like from disrupting this scenic beauty of the ridge line. There is a need for accelerated acquisition of scenic sites and strips by easement and zoning to prevent damaging uses of land.

There is a need for more complete landscaping and maintenance of historical sites. An example would be that farms which illustrate typical rural activity be purchased and set aside by the State.

F. ANADROMOUS FISHERIES RESTORATION

1. General

The four basin States in cooperation with the U. S. Fish and Wildlife Service have agreed to support a fishery program for the basin which has as its objective realization of the full potential of the fishery resources of the basin both anadromous and resident. This work is now under the direction of the Policy and Technical Committees for Fishery Management in the Connecticut Basin. The anadromous portion of this program is chiefly concerned with restoration of the historical runs of American shad and Atlantic salmon. The shad run would be extended from its present upstream limit in the Holyoke pool to the Bellows Falls pool. The salmon run would be re-established primarily through a hatchery smolt-stocking program upstream to the major spawning habitat, such as that in the White and Ammonoosuc Rivers. To realize the full objective of this program, there is a need for action in five areas, namely:

- Fish passage facilities
- Fish hatcheries
- Stream bank access
- Proper interstate regulation
- Low flow augmentation and re-regulation of stream flows.

2. Specific Needs

The objective and requirements of this program are more fully elaborated on in Appendix G of this report. Briefly, however, the needs of this program are as follows:

a. Fish passage facilities at the five major dams on the main stem of the river will be required. Passage facilities at the lower three dams will be designed for both salmon and shad. The facility at Bellows Falls will be designed primarily for Atlantic salmon; however, there will be sufficient use by American shad to provide limited additional benefits.

b. Fish hatcheries are needed to accomplish the salmon restoration program, which has as its goal 40,000 adult salmon at the river's mouth. Salmon hatching and rearing facilities capable of producing some one million smolts will be required. It is expected that the goal of 40,000 salmon will be achieved by the introduction of artifically reared smolts and the maintenance of an expanded smolt-stocking program and natural reproduction in streams such as the White, Cold, and the Ammonoosuc Rivers. The exact number of hatcheries required to produce this total has not been determined, but five locations have been under consideration: one in Vermont, two in New Hampshire, one in Massachusetts, and two in Connecticut. At least two hatcheries may depend on proposed reservoirs for part of their water supply.

c. A key to the restoration program is the acquisition of land so that the public may avail itself of the fishing opportunities resulting from historic runs of Atlantic salmon and American shad. There is a need to acquire sufficient land to provide the necessary public access and this should be incorporated on a multiple-purpose basis with acquisition needs for other purposes such as recreation or resident fish or flood control.

d. To assure the success of the anadromous fisheries restoration program and to attain the coordination necessary to optimize benefits from the program, interstate regulation will be necessary. When the proposed fisheries become a reality, the four States involved will need to cooperate to establish regulation to maintain the fisheries as well as to assure that each State shares equitably in the related fishing opportunities.

e. Adequate minimum flows are essential to the ultimate achievement of the goals of the anadromous fishery program. Preliminary analysis of natural flows in the Connecticut River Basin indicates that from a fishery viewpoint, the instantaneous minimum flow release at the main stem dams along the Connecticut River should be 0.25 cubic feet per second for each square mile of drainage area upstream from the dam in question. The Coordinating Committee for the comprehensive study recognizes the need for adequate minimum flows and has recommended that the power companies maintain a minimum instantaneous release of 0.20 cfs at the existing five main stem power dams with the remaining flows to be provided by releases from new and existing tributary reservoirs. Again, as in the case of stream bank acquisition, increased flows will serve multiple-uses improving both the quantity and quality. It should be noted that these increased flows will also enhance such related uses as recreation and water quality for the resident fish program.

In the salmon restoration program, the White River in Vermont and Ammonoosuc River in New Hampshire are regarded as principal objectives of the program. In addition to these two streams, by 1980 Atlantic salmon are expected to occur in the Salmon and Farmington Rivers in Connecticut, the Westfield and Deerfield in Massachusetts, the Cold River in New Hampshire, and the West River in Vermont.

G. RESIDENT FISHERIES AND WILDLIFE

1. General

Since the time of the early settlers, development of the Connecticut River Basin has gradually encroached upon the available fish and wildlife resources of the basin. Initially, fish and wildlife was important as a major source of food and income for the pioneers. Development of agricultural and other commercial sources has caused the importance of these resources as a source of food to dwindle drastically. However, as the population has increased and urban living has become predominant, these same fish and wildlife resources are now significant in providing a source of income resulting from the demand for outdoor recreation. Demand for recreation opportunities has grown in proportion to increased population, improved traveling facilities, and increased leisure time due to higher incomes and shorter working hours. Surveys of fishing and hunting indicate that in terms of basin population, we should plan for the needs of hunters and fishermen within a population of 1.27 million people in 1960; 1.52 million in 1980; and 2.3 million in 2020. This is representative of that portion of the total population 12 years of age or over.

2. Demand

From field surveys, it was determined that the fishing use of the basin's lakes and streams was approximately 2,650,000 man-days in 1960 as noted in Appendix G. This was attributable to 175,000 resident fishermen and 45,000 non-resident fishermen. The projected demand will exceed 6,500,000 man-days in 1980 and 12,000,000 man-days by the year 2020. Table 22 and Table 23 present the comparison of the optimum development of potential supply versus demand for resident fishery resources in the six Connecticut River Basin areas. Figure 14 shows the need for fishery resources.

3. Need

The need for additional fish and wildlife supply within the basin depends largely on the use that can be made of existing resources. For example, the degree to which existing water supply reservoirs

TABLE 22

Optimum development potential[1/] of supply vs. demand for resident fishery resources (in fisherman-days)

UPPER BASIN

	Supply Total	Supply Local 2/	1980 Demand Without Non-Residents	1980 Demand With Non-Residents	1980 Need Without Non-Residents	1980 Need With Non-Residents	2020 Demand Without Non-Residents	2020 Demand With Non-Residents	2020 Need Without Non-Residents	2020 Need With Non-Residents
Area I, New Hampshire										
Cold-water Streams	395,500	76,600	75,000	202,400	0	0	98,000	364,100	0	45,200
Warm-water Streams	34,600	0	3,800	10,200	0	0	4,900	18,200	0	0
Cold-water Ponds	395,200	11,900	90,000	242,900	0	0	117,600	436,900	0	53,600
Warm-water Ponds	125,900	13,000	18,700	50,600	0	0	24,500	91,000	0	0
	951,200	101,500	187,500	506,100	0	0	245,000	910,200	0	98,800
Area II, Vermont										
Cold-water Streams	297,900	52,200	77,600	137,200	0	0	113,400	273,400	0	27,700
Warm-water Streams	38,000	0	6,500	11,400	0	0	9,400	22,800	0	0
Cold-water Ponds	270,300	8,000	86,200	152,500	0	0	126,000	303,700	0	41,400
Warm-water Ponds	198,800	5,700	45,300	80,100	0	0	66,200	159,500	0	0
	805,000	65,900	215,600	381,200	0	0	315,000	759,400	0	69,100

MIDDLE BASIN

	Supply Total	Supply Local 2/	1980 Demand Without Non-Residents	1980 Demand With Non-Residents	1980 Need Without Non-Residents	1980 Need With Non-Residents	2020 Demand Without Non-Residents	2020 Demand With Non-Residents	2020 Need Without Non-Residents	2020 Need With Non-Residents
Area III, New Hampshire										
Cold-water Streams	182,000	35,000	143,300	232,100	0	85,100	220,500	410,100	38,500	228,100
Warm-water Streams	153,600	0	24,400	38,700	0	0	36,800	68,400	0	0
Cold-water Ponds	291,200	15,000	195,000	309,400	0	33,200	294,000	546,800	2,800	255,600
Warm-water Ponds	539,300	47,700	121,900	193,400	0	0	183,700	341,700	0	0
	1,166,100	97,700	487,600	773,600	0	118,300	735,000	1,367,000	41,300	483,700
Area IV, Vermont										
Cold-water Streams	309,700	73,900	175,100	270,700	0	34,900	289,000	500,200	0	211,200
Warm-water Streams	185,700	0	35,000	54,200	0	0	57,800	100,000	0	0
Cold-water Ponds	146,000	15,000	131,400	203,000	0	71,600	216,800	375,200	70,800	229,200
Warm-water Ponds	155,800	21,700	96,300	148,900	0	14,800	158,900	275,100	3,100	119,300
	797,200	110,600	437,800	676,800	0	121,300	722,500	1,250,500	73,900	559,700

1/ Optimum development potential assumes that pollution will be abated and that adequate public access will be provided (water supply reservoirs currently closed to public fishing not considered; private ponds considered at 50 percent of potential).

2/ That portion of the total supply which constitutes a fishery of restricted or local significance and cannot logically be used to satisfy non-resident fishing demand.

TABLE 23

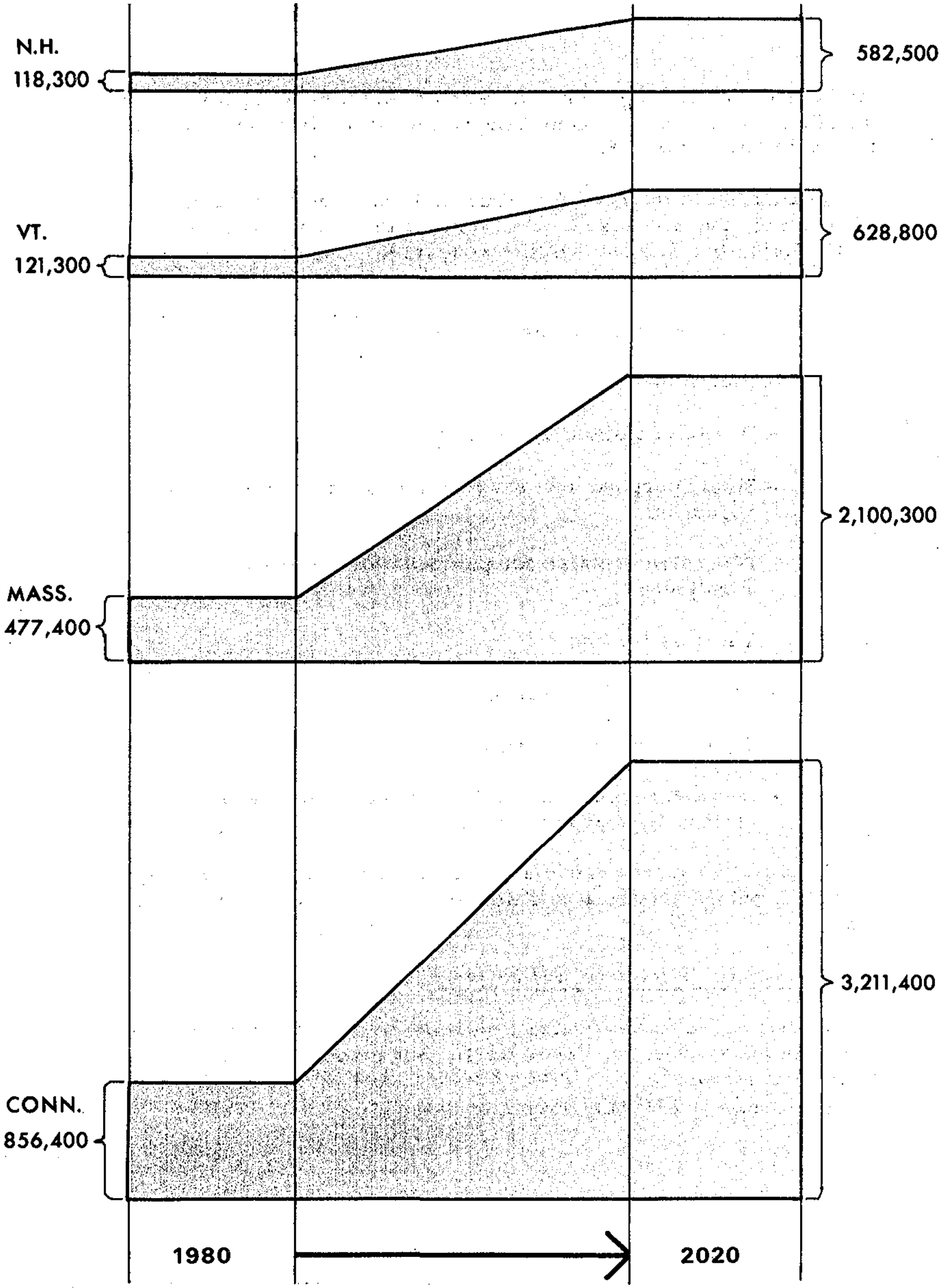
Optimum development potential[1] of supply vs. demand for resident fishery resources (in fisherman-days)

LOWER BASIN

Area / Type Fishery	Supply	1980 Demand: Without Latent Demand	1980 Demand: With Latent[2] Demand	1980 Need: Without Latent Demand	1980 Need: With Latent[2] Demand	2020 Demand: Without Latent Demand	2020 Demand: With Latent[2] Demand	2020 Need: Without Latent Demand	2020 Need: With Latent[2] Demand
Area V, Massachusetts									
Cold-water Streams	406,100	409,600	518,900	3,500	112,800	771,200	942,300	365,100	536,200
Warm-water Streams	414,900	136,600	173,000	0	0	257,100	314,100	0	0
Cold-water Ponds	335,600	512,000	648,700	176,400	313,100	964,000	1,177,900	628,400	842,300
Warm-water Ponds	770,100	648,600	821,600	0	51,500	1,221,000	1,491,900	450,900	721,800
	1,926,700	1,706,800	2,162,200	179,900	477,400	3,213,300	3,926,200	1,444,400	2,100,300
Area VI, Connecticut									
Cold-water Streams	242,700	367,500	482,800	124,800	240,100	846,200	1,057,900	603,500	815,200
Warm-water Streams	443,600	306,200	402,300	0	0	705,200	881,600	261,600	438,000
Cold-water Ponds	241,600	471,600	619,600	230,000	378,000	1,086,000	1,357,700	844,400	1,116,100
Warm-water Ponds	268,700	385,900	507,000	117,200	238,300	888,600	1,110,800	619,900	842,100
	1,196,600	1,531,200	2,011,700	472,000	856,400	3,536,000	4,408,000	2,329,400	3,211,400

1/ Optimum development potential assumes that pollution will be abated and that adequate public access will be provided (water supply reservoirs currently closed to public fishing not considered; private ponds considered at 50 percent of potential).

2/ A measure of latent demand can be obtained if we assume that the difference between National Survey (1960) and Area V and Area VI average participation rates reflect an unfulfilled demand which can be satisfied if adequate fishing opportunities were available within the subarea.



UNSATISFIED DEMAND FOR RESIDENT FISHERY RESOURCES

(IN FISHERMAN DAYS)

FIGURE 14

can be used for fishing. An evaluation of existing and projected unsatisfied demand for resident fishery resources is shown on Table 22 and 23 and Figure 14.

In addition to the need for additional opportunities for fishing and hunting, there is also a need to solve the many problems presently facing the fish and wildlife resources. Significant among these are:

- Lack of public access

- Pollution

- Points of extremely low flow

- Single purpose use of water areas for hydroelectric regulation

- Diversion of water for pumped storage and water supply use

- Thermal loading

- Barriers to fish passage

- Sand and gravel dredging

- Insufficient amounts of fishing habitat in reasonable proximity to population centers.

Wildlife resources capable of meeting needs are also limited by lack of public access in addition to destruction or alteration of habitat.

4. Specific Problems and Needs

Providing adequate fishing opportunities to satisfy future demands is possible in the Upper Basin, but becomes increasingly difficult in the Middle and Lower Basins. The following table shows why the Upper and Middle Basins are so attractive to recreationists:

TABLE 24
AVAILABLE SURFACE WATER AND
STREAM BY SUB-BASIN

CRB	Acres Significant Lakes	Miles Significant Streams	1980 Per Capita Acres Lakes	1980 Per Capita Miles Streams	2020 Per Capita Acres Lakes	2020 Per Capita Miles Streams
I	14,509	796	.439	.024	.372	.02
II	10,285	668	.271	.018	.206	.013
III	15,633	568	.166	.006	.126	.005
IV	7,077	954	.081	.011	.058	.008
V	32,871	1,059	.042	.001	.029	.0009
VI	7,181	495	.007	.0005	.004	.0003
TOTAL	87,553(1)	4,540				

(1) Water supply reservoirs closed to fishing have been omitted.

Most fishermen are not satisfied with .007 acres per capita of fishing water in Connecticut when a 3 to 4-hour drive can take them into northern New Hampshire where .439 acres per individual is available. Also by 2020 stream fishing opportunities in Massachusetts and Connecticut will be even more limited.

One of the most important problems throughout the basin is that of public access. Much of the land is becoming restricted through the use of "No Trespass" signs. Even remote areas are now suffering from the influx of residents in increasing numbers and "No Trespass" signs are becoming common throughout the basin.

Due to development along the shoreline of our ponds and lakes, public access is either limited or unavailable. Unless access was established long ago, there is no room to establish it now. Access is generally limited to private ramps and on many great ponds, shoreline access is non-existent. Assured public access to great ponds is a State and local problem that must be solved preferably by enforcement of existing laws rather than enactment of new ones.

State and Federal streambank acquisition is imperative if the public sport of cold-water stream fishing is to continue on a moderately large scale in the Connecticut Basin. Also, with the restoration of Atlantic salmon and increased runs of American shad, access to streams supporting these species will have premium values. Acquisition now in the public interest is absolutely necessary even though the cost of such acquisition may exceed the cost of all other aspects of the program including species restoration, fish ladders, and necessary hatchery facilities. It is important to note, however, that the purchase of such lands would provide multiple-purpose benefits and would assure recreational access for all future generations. The value of such access is so far-reaching that it should not be weighed against benefits occurring during the normal 100-year project life. Each of the basin States has an active program for acquisition and development to make fishing waters available for public use. Lake and stream frontage, however, is rapidly becoming so expensive that future acquisition for this purpose may be greatly curtailed. It becomes urgent, therefore, that acquisition programs be accelerated if public access for fishing is to be assumed for the future.

Pollution is widespread in the Connecticut River Basin due to a wide variety of industrial, municipal, and domestic wastes. The entire Connecticut River from Groveton, New Hampshire to Long Island Sound, Connecticut can be considered polluted to the degree that it affects fish or fishing. While a vast fishery exists, many fishermen associate the river with pollution and, therefore, hesitate to use its fishery resources.

A particularly bad stretch of river is the 50-mile reach of the main stem between Groveton and Monroe, New Hampshire. This reach includes the 3,500-acre Moore Reservoir which could provide excellent trout and land-locked salmon fishing. From Monroe, New Hampshire to White River Junction, pollution is less severe in this 60-mile reach. However, it is sufficient to deter significant use of the existing fishery resources.

The 65-mile reach of the main stem between Hatfield, Massachusetts and Middleton, Connecticut is polluted due to a combination of domestic and industrial wastes. As noted in Appendix G of this report, the bacteriological quality of the water does not meet the objectives most commonly used by water pollution control agencies. Domestic sewage and industrial wastes produce sludge deposits throughout the main stem of the river from below Holyoke Dam to Enfield Dam in Connecticut. The sludge which covers the river bottom interferes with fish spawning and the development of insect larvae and other aquatic life which serve as food for fish.

In addition to present needs to abate pollution on the main stem, over 400 miles of tributary streams are polluted to a degree which affects fish or fishing. Included are such streams as the Hockanum and Pequabuck Rivers, Connecticut; the Chicopee, Millers, and Westfield Rivers in Massachusetts; the Ashuelot and Sugar Rivers, New Hampshire; and the Black and Ompompanoosuc Rivers, Vermont. There is a need for abatement of pollution caused by industrial, municipal, and domestic wastes so that these resources can be used to meet future fishing demands. It is estimated that elimination of pollution coupled with sufficient public access should result in an increase of 1,000,000 fishermen days valued at $3,000,000.

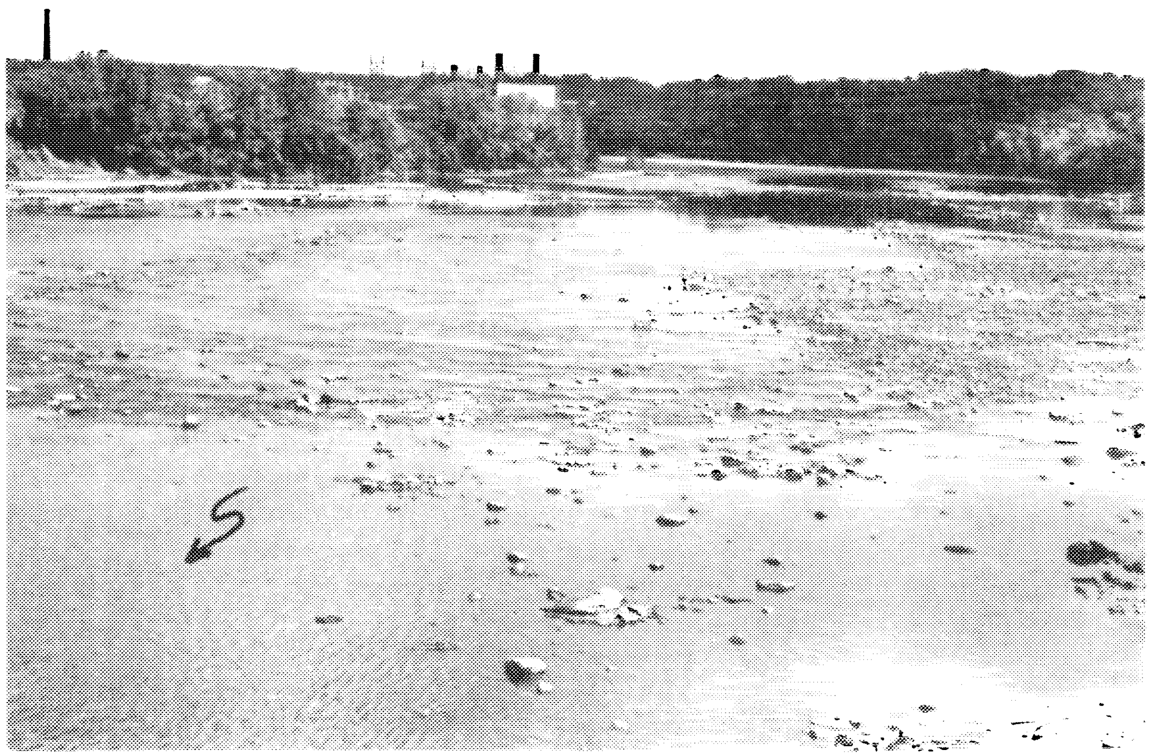
Another source of trouble is thermal pollution which can originate from power generating facilities which use river water for cooling purposes. Large thermal electric plants can cause significant water temperature increases due to their tremendous output capability and corresponding use of cooling waters. It is necessary that such plants insure that resulting water temperatures in the river are not raised to a degree which would have an adverse effect on ecology.

Extreme flow variation characterizes almost all streams in the basin. There is usually too much water during the spring runoff period resulting in bank erosion and bottom scouring while during the late summer flows are reduced to only a fraction of early summer flows and fishing again is severely curtailed. Multiple-purpose reservoir structures capable of providing low flow augmentation could alleviate these stream flow problems. Low flow augmentation from deep cold water reservoirs would greatly benefit most stream fisheries particularly those in the southern half of the basin while water temperatures are above acceptable levels for trout during the warm summer months. The addition of cold water would extend quality stream fishing conditions into and possibly beyond the critical late summer period.

The Coordinating Committee on September 24, 1969 released a "Position Paper" on the relicensing of Wilder, Bellows Falls, Vernon, and Turners Falls hydroelectric projects. The "Position Paper" indicated that a minimum instantaneous flow release of 0.25 cubic feet per second per square mile should be maintained at each of the four structures; that is these flows are necessary for attaining goals of the Connecticut River's anadromous fisheries restoration program now in progress. On this basis, the flow at each dam would be: Wilder - 850 cfs; Bellows Falls - 1,350 cfs; Vernon - 1,550 cfs; and Turners Falls - 1,780 cfs. The Committee concluded that 0.20 csm of the 0.25 csm was the responsibility of the power companies.

As noted previously, the need for public fishing areas is most acute in the southern half of the Connecticut River Basin. The Lower

Basin is more densely populated, water quality control is more acute because of more intensive development, and land owner posting against trespass is more widespread. Although there are many natural ponds and lakes in Massachusetts where public fishing is guaranteed by law, public access is not a certainty unless designated public rights-of-way exist.



WILLIMANSETT RAPIDS SHOWING WEEKEND "DROUGHT" CONDITIONS FROM IMPOUNDMENT OF RIVER FLOWS BY UPSTREAM HOLYOKE DAM

H. WATER SUPPLY NEEDS

1. General

The water resources of the Connecticut River Basin are abundant. The development of this natural resource by municipal and private interests has been extensive. The development of water supply sources in the basin has taken place over many years, with less than 5% of the sources being developed since 1960. Many municipal systems through the years, however, have extended their service, provided treatment facilities or have augmented original sources of supply by the addition of new sources.

The quality of the present water supplies of the Connecticut River Basin is generally good. Throughout the basin only 16% of the municipal systems provide treatment to water, other than disinfection. Within the subareas of the basin, the degree of treatment varies. In general, however, the municipal sources in Vermont and the northern part of New Hampshire do not provide any treatment other than chlorination while the municipal sources in southern New Hampshire, Massachusetts, and Connecticut afford some treatment to over 20% of the number of sources.

Water supply needs were delineated as those requirements within the basin and those requirements out of the basin. An inventory was made of existing or developable sources both surface and ground. Future projections of need were based on anticipated population growth, as noted in the economic projections developed for the comprehensive study. Increases in per capita consumption as well as in industrial consumption were made on the basis of the best available data and are discussed in detail in Appendix D. Rural requirements for domestic needs and livestock are discussed in Appendix F. These latter are projected to increase significantly but would not present a serious problem in the basin owing to the generous ground water supply of the Upper Basin where this activity is concentrated. In the lower tributary, along the main stem, where irrigation demands are currently located, there are adequate river flows.

The basin's total municipal and industrial water supply demand amounts to an estimated 505 million gallons per day, mgd. This demand comes from the basin's municipal water systems and from its industrial complex exclusive of electric utilities and mineral industries.

As population and industrialization of the basin increase, water supply demands will similarly increase. By 2020 the water supply demands of municipalities and industries are expected to more than double the present demand of 505 mgd. Certain areas of the basin can be expected to experience a much greater rate of increase than the basin viewed as a whole.

The sources of water for the municipalities and industries are generally adequate to meet present needs. Similarly, the quality of present supplies poses few problems to the basin's water supply needs. Future demands will necessitate the development of water supply not hitherto utilized due to previous availability of more economically attractive sources.

The projected in-basin demands for municipal and privately supplied industrial water supply in million gallons per day (mgd) are as follows:

	1960	1980	2000	2020
Municipal	178.6	278.8	432.0	663.9
Industrial	326.6	359.9	411.8	463.7
	505.2	638.7	843.8	1127.6

The water requirements for industrial cooling and cooling of thermal electric power generating units are not included in the above figures. These industries, located along the main stem of the river, are the largest water users in the basin; but because they are located close to ample river flows and generally do not consume the water, their demand upon municipal supply systems is small.

2. Municipal Water Supply

a. Consumption

The New England States in 1960 had a population of 10.51 million of which 9.30 million or 89% were served by municipal water systems. In the Connecticut River Basin, approximately 86% of the basin population of 1.68 million people were supplied water from community sources. A breakdown of population and water supply dependency is contained in Section III of this appendix.

Estimates of the water supplied by municipal systems are shown in the following table and represent the average daily amount of water in millions gallons per day, mgd, supplied by community water supply systems to both domestic and non-domestic consumers and is termed the community water supply demand, CWSD.

TABLE 25

COMMUNITY WATER SUPPLY DEMAND

CONNECTICUT RIVER BASIN

1960

	CRB Subdivision						
	I	II	III	IV	V	VI	TOTAL
Community Water Supply Demand, mgd	4.2	2.9	7.5	5.4	84.5	74.1	178.6
Percent of basin cwsd	2	2	4	3	47	42	100

Municipal water systems in New England supplied 1103 mgd in 1960. Table 25 indicates that approximately 16% of this amount was provided from municipal systems located within the Connecticut River Basin. Further, almost 90% of community water supplied by systems in the basin was provided by municipal systems located in basin subdivisions CRB V and CRB VI.

Section III of this appendix indicates that 14 key areas in the Connecticut River Basin accounted for approximately 87% of the total water supplied from municipal systems and constituted from 38 to 98% of the municipal water supplied in each basin subdivision.

Municipal per capita use rates vary within the basin subdivisions. Per capita rates by sub-basin for the years of 1958 and 1963 are shown in Appendix D together with a comparison of the per capita rates for selected municipalities. Usage of municipal water in New England and the Connecticut River Basin averages about 117 and 124 gpcd respectively.

b. **Seasonal and Daily Variations**

As noted in Appendix D municipal water systems are subject to seasonal effects brought about by temporary changes in the location of the population, seasonal operations in certain industries and weather conditions. The popularity of the Connecticut River Basin for recreation and the educational opportunities afforded by the region are the main factors for the seasonal affects experienced. Such variations are created mainly by a large increase in summer residents, tourists, and students.

Variations from average daily demands may also be expected as a result of a combination of factors including the population served, the environment of the community, the amount and type of industry using the municipal system, and the weather.

c. Projections

Projections of community water supply populations indicate that within the basin as a whole the population which will be utilizing community systems will increase in excess of 40% during each twenty-year period up to the year 2000. After the year 2000, the rate of increase will be slightly slower amounting to about 37% increase in the interval between the year 2000 and 2020. Projections of municipal water use in New England indicate that by the year 2000 requirements will double those of 1960. In the twenty-year period from 1960 to 1980 water requirements in New England are projected to increase about 48% and from 1980 to 2000 will increase by about 37%. Projections of community water supply use by sub-basin area are shown in the following table.

TABLE 26
COMMUNITY WATER SUPPLY REQUIREMENTS

Basin Subdivision	Average Daily Requirements in mgd			
	1960	1980	2000	2020
CRB I	4.2	5.9	10.1	15.6
CRB II	2.9	4.5	7.6	11.9
CRB III	7.5	12.1	20.9	34.9
CRB IV	5.4	10.0	17.0	26.5
CRB V	84.5	122.1	183.2	274.5
CRB VI	74.1	124.2	193.2	300.5
TOTAL	178.6	278.8	432.0	663.9

The water required by the industrial complex is utilized for purposes of process water, cooling, and air conditioning and boiler feed purposes. Approximately 8% of the total water use by manufacturing industries is for boiler feed purposes while the remaining 92% is utilized equally between process uses and cooling and air conditioning uses. In the aggregate, future water uses are not expected to vary significantly from the uses reflected by these percentages.

The manufacturing establishments currently supply approximately 85% of the water demand of the industrial complex through private development of surface and ground supplies. The private industrial supplies are expected to provide a similar portion of the total industrial demand in the future.

d. Major Water Using Industries

Although all industries utilize water to some extent, there are selected industries which, because of their processes, use significantly more water than others. The major industries, as used in this report, have been taken to mean the major water using industries. Requirements of major water using industries by sub-basin area are shown in Table 27 . Sources of industrial water in the six sub-basins are shown in the following table.

TABLE 27
SOURCES OF INDUSTRIAL WATER
1960

Basin Subdivision	Use-mgd	Private Sources mgd	Percent Privately Supplied
CRB I	41.6	40.3	97
CRB II	5.5	4.4	80
CRB III	27.7	25.4	92
CRB IV	5.9	3.8	65
CRB V	132.0	106.8	81
CRB VI	173.6	145.9	84
TOTALS	386.3	326.6	85

The use of water by all industrial activities in New England in 1959 totaled 1,949 billion gallons, or a little less than 5% of the nation's industrial usage. In the period from 1954 to 1959, New England's industrial water usage increased by about 117 bg or an increase of 6.4% over the 1954 usage. As compared with the national increase, New England's increase in water usage was about one-third of the nation's increase of 18% during this same period.

Of the 1,949 bg of water used in New England in 1959, 556 bg or 28.5% was used by the manufacturing industries; 1,385 or 71.1% was used by the public electric utility plants; and 8 bg or 0.4% was used by the mining industries.

Although data relative to industrial water usage within the Connecticut River Basin is not available, it is considered that water usage data in the four-State area generally reflects the industrial make-up of the Connecticut River Basin.

Water usage by industrial manufacturing groups in the four States of New Hampshire, Vermont, Connecticut, and Massachusetts in 1959 totaled 405 bg for process, cooling, and air conditioning and boiler feed purposes as compared with a usage of 556 bg by the New England region for similar purposes.

Studies indicate that in the New England region and also in the four-State area, the paper, transportation, machinery, and chemical industries, combined, utilize approximately 70% of the manufacturing industrial water demand. Of the remaining industries in the four-State area, only two industries, rubber and plastics, and primary metals, individually use in excess of 5% of the total industrial usage.

Major portions of the basin's population and municipal water supply requirements are concentrated in certain areas of the basin. Projections were made of the water supply needs of these larger community areas in the basin and are shown in Table 28 . The assumption is that the present systems will be extended in the future to serve contiguous areas not presently served.

e. <u>Supply Capability and Potential</u>

Data from the 1963 inventory of municipal water facilities have been used to determine the supply capability of municipal systems.

A comparison was made of the estimated minimum safe yields of the municipal water systems and future demand by sub-basin. From this comparison it was generalized that by 1980 the municipal water systems in all but sub-basin areas CRB IV and V will be inadequate to meet the future demands. A comparison of future needs and the minimum safe yield of the systems in 14 larger communities is shown in Table 29.

Analyses were made of the capabilities of the nearest stream to furnish the maximum 1980 and 2020 community water supply demands. Indications were that natural flows in the Mascoma, Ashuelot, Saxtons, Mill, Pequabuck, and Mattabesset Rivers would be insufficient to supply the demands of the adjacent municipalities.

In general, the safe yields of municipal sources are adequate to meet current, normal demands. There are a number of municipalities, however, which have current demands approaching or exceeding the recorded safe yield. These municipalities are shown in Table 29.

3. Industrial Water Supply

a. General

The industries within the New England region as well as within the Connecticut River Basin are widely diversified both in industrial output and use of water. These industries include segments of the paper, textile, transportation, food and metal industries.

The basin's industrial complex, exclusive of the public utility and mineral industry, utilized a total of approximately 116 billion gallons of water in 1960 or approximately 386 million gallons per day, mgd. The general trend of industrial development in the basin indicates that significant increases in demands for water may be expected to be exerted by the industrial complex.

b. Projections

(1) Total Projected Industrial Water Use - Projections of industrial water use by the various major water-using industries in the Connecticut River Basin were made by applying an index of the growth of the given industry within the basin. The index selected to reflect the industry's growth was a ratio of the current and projected employment in the industry. The results of these projections are shown in Table 30. These data do not reflect water requirements of the

TABLE 28

COMPARISON OF MINIMUM SAFE YIELD

AND FUTURE DEMANDS OF SELECTED COMMUNITY AREAS

(Core City Plus Area Within 8 Miles of Core City)

Core City	1980 Demand mgd.	2020 Demand mgd.	Minimum Safe Yield[1] of Present Sources mgd.
Littleton, N. H.	2.3	5.3	2.536
St. Johnsbury, Vt.	2.4	5.3	1.589
Lebanon-Hanover, N. H.	4.4	12.5	4.213 (No Limit)
Claremont-Newport, N. H.	2.7	8.1	1.412
Keene, N. H.	4.4	13.9	2.777
Windsor, Vt.	0.6	1.3	2.145
Springfield, Vt.	2.3	5.9	2.631
Bellows Falls, Vt.	1.7	4.9	1.039
Brattleboro, Vt.	3.5	8.9	2.720
Northampton-Amherst, Mass.	13.8	32.5	18.260 (No Limit)
Springfield, Mass.	88.9	204.9	89.750 (No Limit)
New Britain, Conn.	35.9	80.9	19.018
Hartford, Conn.	79.2	189.7	47.682
Middletown, Conn.	9.1	25.4	3.923

1. Safe yield assumed equal to 1963 demand when other data unavailable.

TABLE 29

CURRENT DEMAND AND SAFE YIELD OF SELECTED COMMUNITIES

Basin Subdivision and Community	1963 Demand mgd.	Safe Yield mgd.	Remarks
CRB I			
Northumberland, N. H.	0.325	Unknown	Municipality is studying development of new sources.
CRB II			
St. Johnsbury, Vt.	1.520	1.200	
CRB III			
Keene, N. H.	2.650	Unknown	Municipality will have additional 4 mgd. available from authorized Beaver Brook Dam.
CRB V			
Barre, Mass.	0.369	0.300	
Chester, Mass.	0.309	0.370	
Cummington, Mass.	0.012	0.010	
Deerfield, Mass.	0.409	0.530	
Gill, Mass.	0.020	0.020	
Hatfield, Mass.	0.082	0.110	
Monroe, Mass.	0.033	0.023	
Montague, Mass.	1.500	1.620	
Shelburne, Mass.	0.218	0.180	
Sunderland, Mass.	0.088	0.100	
W. Brookfield, Mass.	0.355	0.500	

TABLE 29 (Continued)

Basin Subdivision and Community	1963 Demand mgd.	Safe Yield mgd.	Remarks
CRB VI			
Bristol, Conn.	6.000	6.900	
Chester, Conn.	1.000	0.430	
Durham, Conn.	0.045	0.043	
Enfield, Conn.	2.284	1.000	
Glastonbury, Conn.	0.072	0.065	
Granby, Conn.	0.072	0.035	
Hartford, County, MDC	42.800	42.800*	*Ultimate development will yield 129 mgd. *Additional 47 mgd. available after construction of tunnel from Hogback Reservoir to Barkhamsted Reservoir.
Manchester, Conn.	3.423	3.360	
Middletown, Conn.	2.540	2.230	
New Britain, Conn.	10.720	10.720	Additional 5 mgd. available from Hartford MDC.
Plainville, Conn.	1.870	0.786	
Simsbury, Conn.	1.040	0.471	
Suffield	0.554	0.175	
Windsor Locks	0.600	0.650	

mineral or electrical industries.

These projections indicate that the industrial water requirements of the Connecticut River Basin will rise by about 44 mgd by 1980 or an increase of 11% over the requirements in 1960. Through the year 2020 the industrial water requirements are projected to increase by 175 mgd or 44% over the 1960 requirements.

Within the basin, the largest increase in industrial water requirement from 1960 to 1980 is expected to occur in basin subdivisions CRB V and VI, where increases of 11.6 and 20.4 mgd, respectively, will be required during this period. In the period from 1980 to 2020, the projected industrial water requirements indicate that a geographical shift in water requirements is projected to occur in basin subdivisions CRB V and I where increases of 57.4 and 33.6 mgd, respectively, will be required.

TABLE 30

ESTIMATED INDUSTRIAL WATER REQUIREMENT

CONNECTICUT RIVER BASIN

Basin Subdivision	Average Daily Requirement in mgd		
	1960	1980	2020
CRB I	41.6	44.0	77.6
CRB II	5.5	10.0	24.1
CRB III	27.7	28.4	38.9
CRB IV	5.9	10.3	23.6
CRB V	132.0	143.6	201.0
CRB VI	173.6	194.0	194.5
Total	386.3	430.0	559.7

4. Diversions

Tables 31 and 32 are estimates of water supply diversions into the basin and basin withdrawals. With the exception of the basin withdrawal for the water supply of Boston, Massachusetts diversions into or out of the basin are relatively minor. In the case of the Quabbin diversion, the 722 mgd would be the diversion rate required if the MDC obtained all its additional requirement from the Connecticut River Basin. Although a significant rate of diversion occurs for the Boston Metropolitan area, this diversion consists essentially of entrapped spring freshets which would otherwise pass downstream. In this respect, the Northeast Water Supply Study (NEWS) is examining the water supply requirements of the Northeast Region and is examining the feasibility of basin water diversions.

5. Summary of Areas of Need

The study finds that the naturally abundant surface and ground water supplies, if properly developed, can meet all projected municipal and industrial needs. The problem arises principally in the allocation of existing supply to Need points, particularly in future years. In New Hampshire, there are a few areas with water supply needs. One of these is in the Upper Ammonoosuc River particularly for domestic and industrial requirements in the village of Groveton. The second area is in the Ashuelot River Basin where a series of industrial firms will need added supply by the 1980 time frame. Several surface alternatives have been located to meet this requirement. Other areas in the State have generally adequate supply and have many favorable surface opportunities that can be readily developed at a reasonable cost within the municipal or local capability.

In Vermont, there are currently few water supply areas in the basin which are not within the potential local or municipal capability. Growth in many small towns may transpose the many individual separate ground water wells into municipal systems in future years, but this should offer no problem to supply.

In Massachusetts the major water supplies are currently located in the urban complex. At present in Massachusetts, there are four major water supply systems. Three of these systems, the municipal water departments of Springfield, Chicopee, and Holyoke furnish approximately 60% of the publicly supplied water needs of communities. The fourth system, the Metropolitan District Commission (Boston), through its Quabbin Reservoir facility furnished, via interbasin transfer, a major proportion of the Metropolitan Boston area water supply needs.

TABLE 31

ESTIMATES OF WATER SUPPLY DIVERSIONS INTO THE CONNECTICUT RIVER BASIN

Basin Subdivision	Source of Diversion	Name & Location of User	Diversion Rate in mgd		
			1960	1980	2020
CRB III	Jaffrey, New Hampshire (Merrimack River Basin)	Rindge, New Hampshire	0.110	0.177	0.51
CRB VI	Guilford, Connecticut (Conn. Coastal Basin)	Old Saybrook Ct. and	0.580	0.975	2.35
		Saybrook Pt., Ct.	0.055	0.093	0.22
	Totals		0.745	1.245	3.08

TABLE 32

ESTIMATES OF WATER SUPPLY DIVERSIONS OUT OF THE CONNECTICUT RIVER BASIN

Basin Subdivision	Source of Diversion	Location of Discharge	Diversion Rate in mgd 1960	1980	2020
CRB I	Upper Ammonoosuc River	Berlin, New Hampshire - Androscoggin River Basin	1.50	2.1	5.6
CRB III	Lake Sunapee	Newbury, New Hampshire - Merrimack River Basin	0.07	0.11	0.33
CRB V	Upper Naukeag Lake[1]	Ashburnham, Mass. - Merrimack River Basin	0.22	5.32	5.72
CRB V	Quabbin Reservoir	Boston, Massachusetts - Atlantic Ocean	140	310	722
	Totals		141.79	317.53	733.65

1. Weyerhauser Paper Company in Fitchburg has plans for diverting 5 mgd from this lake to the Nashua River.

The Springfield system services two cities and five towns with a 1960 population of 240,000. In addition, three other towns with a population of 30,000 may join the system if they desire. In 1965 this system supplied an average daily demand of 40 mgd. The Springfield system's main source of water is the Cobble Mountain-Borden Brook Reservoir complex located on the Westfield-Little River. Together these reservoirs have a combined capacity of 25.3 billion gallons and an estimated "safe yield" of 33 to 35 mgd. A recent addition of storage and transfer facilities from the Corps of Engineers' Littleville Reservoir added a yield of 20 mgd to the Cobble Mountain-Borden Brook yield. Future installation of pumps could add an additional 10 mgd at Littleville bringing the total yield available from the Littleville development to 30 mgd. A second satellite unit of the Springfield system, the Ludlow Reservoir, is located in the Chicopee River Basin. This reservoir has a capacity of two billion gallons and an estimated "safe yield" of 5 to 7 mgd. This older unit supplies water to Ludlow and, for a portion of the year, to the Monsanto Chemical Company in Springfield.

The Chicopee system draws its water from Quabbin Reservoir via the Chicopee Valley aqueduct, a 48 and 36-inch conveyance line which also serves the water needs of Wilbraham and South Hadley Fire District No. 1. The total 1965 population served by the aqueduct was 85,700 of which 66,000 were served by the Chicopee Water Department. The aqueduct was originally designed to transmit 23 mgd to the serviced communities. In 1965 the communities served by this aqueduct were supplied at an average annual rate of 13 mgd.

The Holyoke system supplies all of the water demand for the city of Holyoke. The system is also required to supply a maximum demand of 0.62 mgd to the town of Southampton. The total 1965 population served by the system was 53,000 with an average annual demand of 8.7 mgd. The system's main source of supply is the Tighe-Carmody and White Reservoirs on the Manhan River. Together, these reservoirs have a combined capacity of 5.4 billion gallons and an estimated "safe yield" of 13 mgd.

I. NAVIGATION

1. General

There is a need for increased navigation improvement in the Connecticut River Basin. The needs are centered primarily on the lower main stem of the Connecticut River within Massachusetts and Connecticut although some canoeing needs exist on the upper main stem and tributaries. Major elements of need are as follows:

2. Long Island Sound to Hartford

From Long Island Sound to Hartford there is a need to modify the existing 15-foot deep and 150-foot wide commercial navigation channel project which extends for 52 miles from Saybrook Light up to Hartford. The latest reported commercial waterborne traffic is 3,650,000 tons, which is second only to New Haven Harbor within the State of Connecticut. Based on Office of Business Economics projections, the total is expected to triple by the year 2020. Consequently, there is a need to deepen and widen the present commercial navigation channel and to ease hazardous bends to provide minimum safety clearances for existing 3,000-ton oil barges and for prospective 4,000-ton oil barges.

From Long Island Sound to Hartford, the study also concludes that there is increasing need for provision of a secondary system of navigation buoys to delineate the naturally deep waterway available for recreation boats. This may require authorization of specific limits for Federal recreational-navigation projects to permit Coast Guard participation by the year 1980.

3. Hartford to Holyoke

From Hartford to Holyoke there is a need to improve recreational navigation to permit use of the 33-mile reach of the river from Hartford to vicinity of the Williamansett Highway Bridge at Holyoke. Recreational boating in the Connecticut River above Hartford is now seriously impeded during the prime boating season by major shoals between Hartford and Windsor Locks. The existing 5.3-mile long Windsor Locks Canal, which provides the bypass around the Enfield Rapids and the Enfield Dam, receives very little traffic as most power boats are unable to use the canal during the prime boating months because river stages are frequently too low to permit entrance into the canal and passage through existing shoal areas in the river.

Flow on the river is seriously reduced by the present method of operating the upstream hydroelectric plants for peaking power. The river flows on the main river during the boating season are impounded during weekends and releases are made intermittently on weekdays to meet the demand for peak power.

There is strong demand for the recreational improvement in this reach of the river. Although pollution of the river has, in the past, been a major deterrent to boating growth between Hartford and Holyoke, it is anticipated that the proposed improvement to navigation in conjunction with existing pollution will cause many new boats to be added to the existing fleet at an accelerated rate. Through-passage development of the waterway, also will encourage many transient boats to interchange between inland waters upstream and the tidal waters downstream from Hartford including Long Island Sound and adjacent coastal waters.

In addition to the analysis of needs for recreational boating above Hartford, study was made of the need for commercial navigation in the reach between Hartford and Holyoke resulting in the conclusion that commercial navigation improvements in this reach are not justified at this time. Study also was made of the justification for constructing a hydroelectric power dam and commercial navigation lock at Enfield Rapids and this also was not found feasible for Federal development.

Projections developed by the Office of Business Economics anticipate that the per capita personal income will rise nearly four times by 2020. This rising personal income coupled with population projections and the trends towards more leisure time and mobility are expected to increase the pressures for recreational boating growth in the Hartford-Holyoke area.

The existing recreational fleet in the Hartford to Holyoke area is considered to consist of the equivalent to 50 boats based in Connecticut and the equivalent of 150 boats based in Massachusetts. The Connecticut fleet consists of 20 berthed boats and over 4,500 boats that are launched from some eight facilities mostly during the May to June shad fishing season. These 4,500 launchings are considered to be equivalent to 30 boats berthed full time locally. The Massachusetts existing fleet consists of some 110 berthed boats and 6,000 boats launched from some seven areas, considered to be equivalent to 40 boats berthed full time locally.

Because of existing shoals and low river stages that prevail during most of the summer and early autumn boating season, relatively few transient boats attempt to cruise upstream from Hartford. Wethersfield Cove, which is located about four miles south of Hartford, presently serves as the upstream stopover point for most transient boats cruising the Connecticut River.

It is expected that other recreational navigation improvements in the form of local requests for improvement to potential off-channel small boat basins will be required when the Hartford to Holyoke improvement is implemented.

4. Main Stem Above Holyoke

There is a need for provision of additional access ramps at designated points along the perimeter of the significant reservoir areas behind the power dams on the main stem river at Holyoke, Turners Falls, Vernon, and Bellows Falls. As use of the Hartford to Holyoke recreational project develops, there may be a need for measures that would enable boats to bypass these main stem dams during the boating season. As this need develops and the magnitude of the need can be assessed more properly, a determination can be made as to whether the bypassing should be initially done by trailer services or by permanent structural measures.

Navigation-aid buoys are needed in varying degrees in the Holyoke, Turners Falls, Vernon, and Bellows Falls pools while minor ledge and shoal removal is needed in the Holyoke pool. Due to existing and anticipated boating use of the Holyoke pool, there is present need for provision of a small-boat channel within the lower 13-mile reach of this reservoir as well as continuing interest for extending channel improvements upstream to Greenfield.

5. Upstream Needs

Assessment was made of the upper and middle reaches of the main river and those tributaries on which canoeing could be enhanced by augmentation of low flows. Generally speaking, it is difficult to justify creating reservoir storage to provide flow for year round canoeing. Reaches of stream of white water canoeing potentially are, by their very nature, relatively steep and require large stream flows to maintain safe depths. It is rarely feasible to provide storage for the augmented flows required for canoeing purposes. In some instances, however, it is possible to improve canoeing on streams where the sport is presently only possible on a marginal basis. Where possible, the study recognizes the need for an extension of the canoeing season to provide full opportunity for family enjoyment of this sport. Therefore, it is expected that as projects are developed, that canoeing will be included as a flow augmentation purpose if compatible with the other uses for which the project was intended.

J. LAND MANAGEMENT AND UPSTREAM WATERSHED CONTROL

1. General

Of the 7.1 million acres of land and water in the Connecticut River Basin, 79% is in forest, 9% is cropland, 4% is pasture, 4% is urban and built-up areas and the remaining 4% is in other categories. Through the study period up until the year 2020, much of the land presently used for crop and pasture is expected to revert to forest. At the same time, there will be a considerable increase in urban and rural residential acreage. This latter competing shift will keep the percentage of forest lands essentially the same at 79% while the cropland will drop to 2% and pasture to 1%. Urban and built-up areas by 2020 will comprise 10% and the remaining 8% will be in other categories. One of the reasons for the reduction in cropland is that this category of use is largely for hay and pasture and there is anticipated to be a decrease in the acreage required for dairy use.

At present more than 85% of the land in the basin is privately owned by individuals or corporations with the remainder publicly owned. Of the privately owned, 1.7 million acres are owned by farmers and 4.5 million acres by other private owners including land in urban and built-up areas. Public ownership comprises less than 15% of the total land and water in the basin and is distributed in 306,600 acres of National forest land; 410,000 acres of State, county, and municipal lands; and about 17,000 acres of other Federal lands including Corps of Engineers' reservoir projects. Much of the land in public ownership is in forest.

Of the basin's 1960 population of 1.7 million, 72% lived in cities and towns with the remainder in rural areas. The rural sector is made up of a farm population of about 50,000 people and those people in villages of less than 2,500 population. The urban population is largely concentrated in Massachusetts and Connecticut portions of the basin.

2. Agriculture

There are 1.1 million acres of productive crop and pasture land in the basin suitable for agriculture use with only minor problems from erosion or other hazards. The problem is that there will be heavy demands for these lands from other competing uses and it will be necessary to reserve land which is adapted for agricultural uses as well as to satisfy environmental quality needs. It will be difficult to reserve land for agriculture which does not require land treatment, in the face of this increasing competition from other uses.

Crop and pasture land is projected to decline from a total of 938,000 acres in 1965 to 400,000 acres by 1980 and 138,000 acres by the year 2020. These changes will be the result of expected urban expansion, the phasing out of shade-grown tobacco, the adoption of more intensive agricultural techniques, and the shift of less productive land to forest. Current indications are that these shifts in land use are well under way.

Based on the revised 1967 USDA Conservation Needs Inventory, 204,000 acres of crop and pasture land need land treatment. Included are measures for erosion control, drainage, irrigation, and establishment of vegetative fertility management. Continued maintenance of conservation practices is required on all lands.

3. Forest

Much of the privately-owned non-industrial forested area is contributing less than its full potential to the economic growth and welfare of the basin. Over one-third of the forest land is in poor to very poor hydrologic condition; however, the potential to improve is generally high. Multiple-use management and protection is needed to realize these potentials as well as the continued yield of high quality water and better regulated runoff. Timber quality is low, land values and related taxes are becoming excessive, and many forest landowners are more interested in the recreational and aesthetic uses of their lands rather than timber production. Multiple-use management and land treatment measures are needed on about 4.5 million acres of private, non-industrial forest land. This figure contains a duplication of acres since some acres of forest land may require more than one treatment to meet identified needs. This will require a greater conservation education effort and additional incentive programs to the landowner if the forest resources are to be fully developed and utilized. Many small municipal watersheds are not under management, and technical assistance is needed on nearly 64,000 acres of National forest land.

4. Urban and Built-Up Areas

The expanding population, projected to double by the year 2020, will require much reconstruction in the city areas, greatly expanded suburban developments, and large numbers or rural homes in the outlying areas. The construction of facilities for servicing this population in the form of shopping centers, highways, and park areas will involve much of the better land, especially in the lower basin. Adequate planning, including the use of soil surveys, is essential in this development to maintain proper land use; avoid additional flood hazard by zoning flood-prone areas to appropriate use such as parks, open space, and agriculture; control erosion and resulting sediment problems to the maximum extent during construction activities; develop and maintain adequate vegetative cover and waterways to minimize damage from runoff and erosion.

The need for protecting existing water surface areas and the development of new water bodies and open space plus the need for improved and increased wildlife habitat are also essential to maintain a quality environment.

The environmental quality provided by trees and other vegetation in many urban areas and communities is deteriorating, and their importance is often inadequately considered in the development of new communities. Community action, planning, and management of trees and other vegetation are needed for improvements of sylvan aesthetics and microclimate control.

5. Specific Needs and Problems

a. Studies by the Soil Conservation Service of the Department of Agriculture show there is a need to reduce the $2.1M of average annual damages sustained in the 141 upstream watersheds of the basin and to protect rural communities and agricultural areas from flooding. The total flood plain acreage is estimated at 59,000 acres of which 26,000 are in agricultural use; 1,900 are urban; and the remainder 31,100 is either forest or in miscellaneous use. Appendix F discusses the extent of flood water and sediment drainage in these upstream watersheds.

b. There is a need for acceleration of present U.S. Department of Agriculture programs to guide land use adjustments and to retain the most suitable lands for agriculture and environmental quality. Essential programs needing acceleration are:

(1) Assistance to 180 towns which include preparation of resources inventories, town soil reports and interpretations and flood plain studies

(2) One-half million acres of soil survey.

These two programs are needed as tools for State and local units of Government to guide land use development and management.

c. Land treatment and management measures are needed on over 1.2 million acres of non-Federal land. This would include planning and installing conservation measures and proper management on 204,000 acres of crop and pasture land, 150,000 acres urban and other land, and approximately 823,000 acres of private, non-Federal forest land for the early action plan.

Land treatment will be needed on an additional 3.6 million acres which includes 50,000 acres of crop and pasture land, 150,000 acres of urban and other lands, and 3.4 million acres of private forest land for the long range program. Also needed in the long range program is resource planning assistance to 188 towns in the basin and 3 million acres of soil surveys.

d. Land treatment and management will be needed on nearly 64,000 acres of National Forest land for the Early Action Plan. Soil surveys and watershed analyses will be needed on approximately 306,000 acres of National Forest land and, in addition, watershed analysis studies are needed on 30,500 acres. Some 69,300 additional acres within the Proclamation Boundry of the Green and White Mountain National Forests will need to be acquired for the Early Action Program.

K. SOLID WASTE DISPOSAL

Very few communities in New England have more than a 10-year program for the adequate disposal of solid waste so it is difficult to bring the aspect of solid waste management planning into the 50-year period associated with water resources planning. However, all of the New England States now have Federal grants for the development of State solid waste management plans. These plans are presently being developed and will incorporate regional operations as an alternative to individual community solid waste disposal programs.

Dumps with open burning are being outlawed and replaced with sanitary land fill operations. Land area requirements are increasing under present practices, but developments in volume reduction through reuse, improved incineration, compaction, and shredding will tend to stabilize or lower area requirements for final disposal.

Land allocation for sanitary land fill sites is a pertinent subject to discuss in connection with water resources and related land-use planning. Regardless of the development of solid waste reduction techniques, the final residue will have to be disposed of on the land unless a safe ocean disposal method is devised. Land must be made available for sites and with mounting pressures for land use by other interests this could be a future problem. The State solid waste management plans may identify the areas in New England where there will be a shortage of secondary land fill sites.

The urban areas such as Hartford and Springfield will probably have the greatest difficulty in obtaining land fill sites in the future. The additional cost for long distance hauling of solid wastes away from these urban areas could give economic justification to the establishment of local facilities which would provide a high degree of volume reduction before transporting the wastes to a land fill. The rural areas in the basin will probably be able to dispose of their solid wastes in rural land fills without encountering insurmountable land acquisition problems.

L. PUBLIC HEALTH ASPECTS

1. Air Pollution

Air pollution is caused by many operations which vary from large industrial complexes to the burning of leaves in the neighborhood yard. Since the problem is so varied, this Appendix will limit itself to discussion of two areas which are most affected by water resource development. These are power generation by fossil fuel plants and solid waste reduction by open incineration. The chief cause of air pollution from power plants is the sulphur dioxide which is the product of incomplete combustion. It combines with water droplets in the air and can be transformed into sulphuric acid which results in eye and lung irritation, from breathing this waste produce. Unsightly smoke and particulate matter will also result from this combustion. Although this may not be harmful or as harmful as the sulphur dioxide from a health standpoint, this particulate matter does act as a cost to society in decreasing visibility and in making the surrounding area dirty.

In regard to solid waste disposal, many present techniques utilize the burning of waste material. The first that comes to mind in the largely rural areas is the burning of open dumps. The burning of these dumps puts a strain on the economy by producing air pollution both visual and ordorous, and increasing forest fire potential around the dump site. For the more urbanized area, refuse incinerators, a volume reduction technique, can intensify air pollution if proper controls are not used. The incineration process, in general, produces emissions of fly ash, smoke, gases, and odors. The fly ash and odors are undesirable mostly because of their nuisance potential to nearby communities.

Smokes and gases which have a nuisance potential contribute to overall air pollution through reduction in visibility and ability to enter into smog forming photo chemical reactions in the air. Because of the concern of responsible State and local authorities in the northeast, strong air pollution control programs have become common. The Clean Air Act, as amended, emphasizes the fact that all levels of Government must cooperate in the proper management of our atmosphere. Today States and major urban centers almost without exception have attained authority to control air pollution within their boundaries and have moved to establish workable enforcement programs designed to implement their legal authority.

To avoid air pollution problems it is necessary to anticipate those problems and to plan for necessary control action. Land control actions may involve land use planning for such things as buffer zones around major individual sources but more likely they would involve the choice of direct controls at the source. Direct controls could result in the elimination or minimization of pollutant generation through a process of raw material change. One form of direct controls might be to capture the pollutants after they have been generated but before they reach the atmosphere.

To accomplish the required problem anticipation and control actions, planning could be accomplished through coordination between those engaged in water resource development programs and the area's air pollution control authorities. This coordination should be established at the earliest possible moment.

2. Water Pollution of Shellfish Crop Areas

Consumption of raw shellfish from polluted growing waters can bring about transmission of many known diseases such as infectious hepatitis, typhoid fever, and gastrointeritis. The Connecticut River Basin estuary contains shellfish resources in the form of soft and hard-shell clams, although the quantity present is not known. The reason for this is the estuary is not open to the harvesting of shellfish and has not been for a number of years; consequently, data on shellfish densities are not available.

The estuary is closed to shellfish harvesting because the bacteriological quality of the overlying waters exceeds the allowable limit. As the basin States move to meet the water quality standards the question of whether the shellfish grounds may be opened will be asked. At the present time, it cannot be said with certainty whether the pollution abatement measures will be extensive enough to improve water quality in the estuary to permit shellfish harvesting. It may be that in the future the estuary's classification will be limited to a maximum classification of "Conditionally Open". This means that the water quality meets the required standards but that the chance of contamination is great enough to warrant close surveillance. This classification would give the State Health Department the authority to close the area at the first sign of contamination.

3. Vector Controls

The term vector means an insect that directly or indirectly either transmits a disease agent to man or causes irritation to human beings. This subject is discussed in detail in Appendix R of this report, but a generalized listing of vector problems and needs likely to develop by the year 1980 as a result of projected water resources development, water useage patterns, and other expected ecological changes follows: (1) An increase of the northern house mosquito problem due to increased polluted water; (2) A gradual increase in the size, number, and scope of mosquito control commissions and programs; (3) More emphasis in mosquito control programs and water management and source reduction; and (4) A need for better commissions and cooperation between all affected departments and interests in the solution of this problem, and in the decisions involving water resources management and vector control technology.

In looking forward to the years 1980 and 2020 experience seems to indicate that vector control problems as related to water resource development will not change radically. The four previously noted slow-moving trends will probably continue to occur. In addition, the following projections are made:

(1) The expected increase in size and number of on-stream storage reservoirs for drinking water purposes will be beneficial to mosquito control.

(2) The expected increase in dams for flood control purposes will be beneficial for mosquito control and adverse effects will be greatly overweighed by the beneficial effects.

(3) Increases in temperatures in impoundments and streams due to atomic energy plants are due to present some ecological changes. However, vector problems will probably not be affected in magnitude.

(4) More intensive irrigation of crops will be largely accomplished by overhead sprinklers and will not significantly affect vector problems.

(5) The projected large increase in water-oriented recreation will tend to increase vector control needs. Wherever possible, these needs should be met by on-going vector control programs.

(6) The projected increase in organic pollution of reservoirs, lakes, and streams will tend to increase chironomid midge problems which should be adequately controlled by vector control programs.

(7) The incidence of Rocky Mountain Fever and other vector-borne diseases will probably not change radically.

(8) The research on genetic methods in vector control will probably increase.

4. <u>Radiation Control</u>

Radiation control is linked closely with water resources planning particularly in the design and operation of nuclear plants. The water used to cool the steam is important not only from the quantity of water used and the possibility of thermal increases but also because there is a potential, although very slight, of releasing radioactive materials back into the water course.

The two nuclear power stations operating in New England at the present time are located in the Connecticut River Basin. One is at Rowe, Massachusetts and the other is at Haddam, Connecticut. A third nuclear plant will be located in Vernon, Vermont on the main stem of the Connecticut River.

The Atomic Energy Commission has moved with the nuclear power industry to produce one of the best safety records of any industry both for in-plant personnel and for the surrounding environment. Nuclear power plant's are designed so that even if major accidents occur, the release of radioactive material to the surrounding environment will still be below the maximum limits for radioactive content of air and water set by the Atomic Energy Commission and State Health Departments. Comprehensive monitoring systems are built into nuclear plants to keep a close check on the amount of radioactivity present in the discharge water. Standby units are used to keep a continuous monitoring check on the discharge water should the regular unit break down. The monitoring requirements for on-site surveillance are established and enforced by the Atomic Energy Commission; and although the testing itself is carried on by the power company, it is under the supervision of the Atomic Energy Commission. Monitoring near the site is usually done by the State Health Department.

5. <u>Thermal Effects</u>

There is a growing concern over the possible effect thermal pollution, originating from the discharged cooling water of these plants, would have on the ecological balance of the stream into which the water is being discharged. It should also be noted that fossil, as well as nuclear fuel plants, can create thermal pollution.

The generally accepted feeling is that a small rise in temperautre (1^{o} to 3^{o}) will probably not have any detrimental effect on the balance of the stream. However, when temperatures rise more sharply, it could cause the die-out of a particular plant or animal that is part of a food chain. All species of plants and animals may be affected by the loss of a vital link in a food chain and an ecological disruption in the water environment could occur.

The design of nuclear power plants usually includes a holding basin after the plant to allow heated water to cool. If more cooling is needed, cooling towers could be used.

One of the problem areas for New England involves the disposal of spent fuel not only from nuclear power plants but also from medical, industrial, and research sources. Processing of spent fuel can be accomplished only through sophisticated technology and highly specialized personnel. It usually consists of concentrating the radioactive material and burning it in protective containers at one of four or five land fills throughout the country. The closest processing plant for New England is in Albany, New York. With the growing use of radioactive materials in New England, it may be necessary to locate a spent fuel processing plant in New England.

M. ESTUARY

1. General Description

Of its total length of 400 miles, the main stem of the Connecticut River is tidal for 60 miles from Long Island Sound upstream to the confluence of the Scantic River, eight miles above Hartford. This reach is shown in Figure 15 . From Portland north the tidal water's ebb and flow in the broad terraced valley bordered by hills of the Connecticut Valley Lowlands. Below Portland, the estuary lies between the western hilly section of the southern New England upland to the west and the rolling plateau of the same upland to the east. Much of the upland is forested, while the lowlands provide soil suitable for farming. Near its mouth, the river is bordered by some important wetlands.

The fresh water flow (measured at Thompsonville, near the Massachusetts line) averages about 15,900 cubic feet per second after adjusting for storage and diversion. In water year 1967, the minimum mean daily flows of 84,000 and 1,550 cubic feet per second, respectively, occurred in the months of April and September. Monthly totals show that these were the months with the greatest and least total volume flows, respectively, differing by four orders of magnitude. During periods of low river flow, the tidal range decreases from 3.5 feet at the mouth to more than one foot at Hartford.

During the summer low flow periods, dilute salt water may penetrate up river as far as the East Haddam Bridge. Generally, the salt is found only half as far, and during periods of high river flow and under appropriate wind and tide conditions may barely reach the Saybrook Bridge. Under average conditions, the volume of salt water entering the estuary from Long Island Sound during one tidal cycle is about half the fresh water volume entering during the same period.

2. Population

Study projections indicate that sub-basin area CRB VI will be that fastest growing area in the entire basin and that the population will more than double by the year 2020. As noted in Appendix P the rate of growth for communities adjacent to the tidal portion of the river is almost half again as great as that for the State as a whole (except for Hartford which is already densely populated). Connecticut Inter-Regional Planning Program population projections furnish the conclusion that the growth rate in the estuary and Midstate Planning Region towns is projected to be much faster than the Capitol Region. This fact reveals the pressures which will be exerted on the lower estuary; consequently, the land use pattern chosen to accommodate the several hundred thousand additional people expected to settle along the estuary will be a major determinant in the future of the area.

When viewed from the river, the chief signs of urban population are at Hartford, East Hartford, and Middletown. Elsewhere the density appears relatively low, although individual private homes are prominent along certain stretches of the river.

3. Manufacturing and Industry

Manufacturing is one of the most important industries in the estuary. Aircraft engines and parts manufacturing in Hartford County account for 13% of the total State employment and 40% of the county employment. This industry is also the largest single user of water in sub-basin CRB VI.

Other large users of water in the estuary are the three thermal electric plants which depend on river water for cooling their condensers. From north to south these power plants and their size are:

- South Meadow at Hartford - 217,000 kw
- Middletown at Middletown - 422,000
- Connecticut Yankee at Haddam - 463,000

4. Land Use

Of the 135 miles of estuary shoreline below Hartford, 38 miles are built up or committed, 24 miles are zoned for residences, and only another 3 miles are easily developable and zoned for commercial or industrial use. The remaining 70 miles would require expensive site preparation prior to industrial or residential development.

North of the Charter Oak Bridge in Hartford only one mile of vacant land is zoned for industrial or commercial use and 8 miles are zoned residential. The remaining 13 miles would require expensive site preparation. Over 2,000 acres of industrially-zoned vacant land in lots of ten acres or more were found within a half mile of the navigable portion of the Connecticut River, chiefly in the Hartford-Glastonbury and Cromwell-Middletown areas. However, because of landform problems not all of this land would be usable by firms requiring waterborne shipping.

Just below Middletown, at Bodkin Rock, the river turns southeast and cuts a narrow valley with no flood plain through relatively hard igneous and metamorphic rock. The narrow section (straits) beginning at Bodkin Rock acts as a hydraulic control on the river. The river valley upstream serves as a storage basin during times of flood. The greater the river volume flow, the faster the current flows through the straits; the faster the current, the higher the surface elevation; and the higher the elevation, the more flooding in the valley upstream. It was found that if development or diking decreased the valley storage utilized by the greatest flood of record (1936) by 10% or 30%, the flood crest elevation at the Massachusetts line would be increased by one foot or seven feet, respectively.

In recent years significant land development has taken place along both banks at the mouth of the river, in the form of subdivision and summer homes. This section of the river is a prime recreation and boating center with existing marinas already occupied and new marina sites at a premium. The pressure of the boating public for additional facilities is tremendous to convert tidal wetlands into marinas to serve this demand. Consequently, there is a need for land-use planning to provide for these pressures with minimum destruction to the environment of the estuary.

There are no figures presently available for the amount of wetlands in sub-basin CRB VI; however, statewide coastal wetland inventories show the following decreases in total acres:

Year	Coastal Wetlands (acres)
1914	23,360
1954	17,018
1959	15,927
1964	14,839

In the short span of 10 years, 2,179 acres - about 13% of the 1954 acreage - were destroyed or so altered as to be no longer of value to fish and wildlife as an important element in the food chain. Although the 13% decrease is a statewide figure, and the Connecticut River Estuary has not been so drastically affected, it does point up what the future could hold.

The Connecticut River Estuary also contains a number of sites of cultural and educational interest which are discussed in both Appendix O and P of this report.

5. Recreation and Boating

As previously noted in Section V - D of this Appendix, there is a strong demand for recreational opportunities along the lower Connecticut River. The navigability of the river furnishes an opportunity for boats to travel upstream into the pool of the Enfield Dam. Proposed improvements are needed to accommodate the anticipated traffic, as far upstream as Holyoke, Massachusetts. Additional boating access and/or anchorage facilities will also be required. Table 21 of this Appendix illustrates the large future demand which is projected for boating activity in CRB VI. The subject of recreational as well as commercial navigation needs is discussed more fully in Section V- I of this Appendix.

N. FLOOD CONTROL

The flood history of the Connecticut River goes back more than 300 years to the establishment of the first settlements in the basin. The industrial revolution that followed led to the development of industry along the river where one of the great requirements was readily available water for power, process water, and easy accessibility to market areas. As progress continued, cities such as Hartford, Connecticut; Springfield, Massachusetts; Bellows Falls and Brattleboro, Vermont with billions of dollars of investment eventually enveloped the surrounding area, admittedly often in the flood plains. In ensuing years, floods of great magnitude proved this was not the wisest of choices.

After the historic flood of November 1927 the Corps of Engineers was charged by the Congress to review the problems and develop a plan to minimize future damages. Shortly after completion of that study report, the historic and double-barrelled flood of March 1936 caused extensive damage. Once again, the Corps of Engineers was delegated to review its previous plan. Evolving from that review was a plan consisting of 20 reservoirs and several local protection projects at major damage centers.

More recent floods of lesser magnitude have initiated studies resulting in certain additions or substitutions to the original flood control system. The present authorized plan would control about 27% of the intercepted drainage area at Hartford, Connecticut by construction of 27 reservoir impoundments which would provide the needed flood protection along the main stem of the Connecticut River and its tributaries. Of the 27 reservoirs, 16, controlling 15% of the drainage area together with 15 local protection projects have been constructed throughout the basin. Of the latter, seven are located on the main stem and were designed to supplement the reservoir system.

To assure that the authorized flood control plan conformed to new criteria brought about by changes in times and conditions, the plan was re-evaluated as part of the comprehensive study. Re-evaluation considered the effectiveness of the reservoirs when acting in a system to protect the basin. As part of the re-evaluation process the comprehensive basin study carried out a review survey of damages in all areas subject to flooding and estimates were made of the experienced and recurring flood losses. This survey covered the updating of data to reflect price level charges since the earlier surveys, new evaluation of flood losses to residential, commercial, industrial, public, and utility interests as well as addition of new improvements subject to flood loss. Owners and managers of property were interviewed and assisted in evaluating losses. The data were recorded and tabulated by area and reach of stream. Direct physical losses as well as non-physical losses such as loss of wages, profit and emergency costs were evaluated and recorded.

In monetary value, the effect of the 1927 flood in Vermont exceeded $20,800,000. On a per capita basis, this cost amounted to $196 in a State where per capita income was $600 at the time. The after effects of the flood were a major drag on the economy of the area for the next two decades.

The most serious flood problems in the Connecticut River Basin are on the main stem and the major tributaries such as the Passumpsic, the Ammonoosuc, the White, the Mascoma, the Ashuelot, and the Westfield. Major damage centers on the Connecticut River itself are in the metropolitan areas of Massachusetts and Connecticut, although significant losses also occur at White River Junction, Hanover, Windsor, Bellows Falls, Brattleboro, and Hinsdale. Experienced flood losses in the entire basin for major floods in the twentieth century have exceeded $264,000,000 with 74 lives lost and untold misery not measurable in statistical value.

TABLE 33
FLOOD LOSSES OF FOUR HISTORIC EVENTS
CONNECTICUT RIVER BASIN

Date of Event	Number of Lives Lost	Reported Monetary Damage
November 1927	21	$ 29,000,000
March 1936	11	66,400,000
September 1938	8	48,500,000
August 1955	34	119,000,000

A recurrence of the March 1936 flood under 1970 conditions without flood control measures would cause losses amounting to over $223,000,000. With the implementation of the existing flood control system of 16 reservoirs together with 15 local protection projects at major damage centers, these 1936 recurring losses have been reduced to $26,000,000. Although this represents a substantial reduction in flood losses, it does not present a true picture of the potential for catastrophic flood losses which actually exist in the basin. Such a situation would occur if the major local protection projects on the main stem of the Connecticut were overtopped.

The major local protection projects on the main stem of the river were designed and constructed on the assumption that the entire authorized basin flood control systems, controlling 25% of the intercepted drainage area at Hartford, Connecticut would be completed. An analysis of possible storm and flood conditions shows that the possibility exists for floods, much greater than those experienced in March 1936, to occur. In fact, floods of greater intensity than that of 1936 occurred on certain tributaries in 1927, 1938, and 1955. Should such an intense major basin flood occur, then the existing protection works on the lower main stem of the Connecticut, excluding the works at Hartford, would be overtopped and immeasurable damages and untold havoc would be caused.

The economy of the basin is an expanding one with population expected to almost double in the next 50 years and urbanization, as measured by available developable area, to more than triple. Such growth will result in increased usage of the flood plain. This is because in urbanized areas flood plains often appear to be the most economical areas to develop. Service and transportation facilities are usually available and land outside the flood plain, available for development at reasonable cost, is limited. Consequently, if left unchecked, growth will occur on our flood plains and flood damage potential in the basin will increase in future years.

A discussion of damage centers on the main stem and the major tributaries is contained in Appendix M while those in upstream areas of the basin are discussed in Appendix F. A brief discussion of flood damages in upstream areas is presented in the following paragraphs.

Average annual flood water and sediment damage in the upstream areas of the basin totals approximately $2.1 million at present price levels. These damages occur on 50,000 acres of upstream flood plain land as shown in Table 34. The location and extent of damage areas are shown in detail in Appendix F of this report, however, in general, flooding may be experienced on the flood plains of all reaches of the main stem and its tributaries and few communities have escaped damages from one or more of the major floods such as occurred in 1927, 1936, 1938, and 1955. During such storms highly developed industrial, commercial, and residential areas received major damage. Generally, these highly developed upstream areas sustain minimal damages in the more frequent floods.

Flooding on agricultural land occurs primarily from snowmelt runoff which normally produces annual flooding in the lowest areas; consequently, these areas are usually in pasture, permanent grass or idle. Cropping of land less subject to spring flooding is practiced with relatively little damage.

TABLE 34

LAND USE OF AREAS SUBJECT TO FLOODING
IN UPSTREAM WATERSHEDS 1/

Reference Subdivisions	Land Use (acres)					
	Crop	Pasture	Forest	Urban	Miscellaneous	Total
CRB I New Hampshire	4,450	2,400	2,200	150	2,300	11,500
CRB II Vermont	2,990	2,680	1,850	190	1,950	9,660
CRB III New Hampshire	920	1,020	920	130	1,850	4,840
CRB IV Vermont	3,840	2,690	3,020	330	3,320	13,200
CRB V Massachusetts	860	1,650	2,460	350	5,500	10,820
CRB VI Connecticut	720	1,560	1,670	740	4,290	8,980
Basin Total	13,780	12,000	12,120	1,890	19,210	59,000

1/ Based on estimated area inundated by a 100-year flood.

Studies by the Department of Agriculture on upstream watersheds indicate that floods resulting from severe rain storms during the growing season cause serious crop damage. They have an approximate five-year frequency of occurrence on lower areas of flood plain but are less frequent on the higher more intensively used flood plain areas.

Of the total annual direct non-agricultural damages of 1.6 million dollars in upstream areas, the study indicated that about 70% was to urban property in the towns and villages, 26% to roads and bridges, and about 4% to utilities. The indirect damages of about $300,000 are distributed in about the same proportion.

During the recent major floods - 1927, 1936, 1938, and 1955 - damages on tributary streams, to transportation facilities such as roads, railroads, and bridges, were the major part of the total. Future damages from recurrence of major storms will have a much lower percent of the total damage to these same facilities due to abandonment of many branch line railroads, enlargement of bridges, and highway relocations.

If major developments should occur in flood-prone areas, urban damages can be expected to increase substantially. However, it would appear that more towns and cities should follow the lead of communities in the State of Connecticut. About one-half of the flood-prone areas are zoned to restrict development in these areas.

Average annual damages to agriculture from flood water and sediment are estimated at $165,000 in the upstream portions of the basin. It is important to note that these estimates do not cover the flood plains of the main stem of the Connecticut downstream from Lancaster, New Hampshire and of the main tributaries with drainage areas in excess of 250,000 acres. About 65% of the agricultural damages are to growing crops and pasture and 35% to fences, farm roads, and other improvements.

O. FLOW REGULATION AND AUGMENTATION

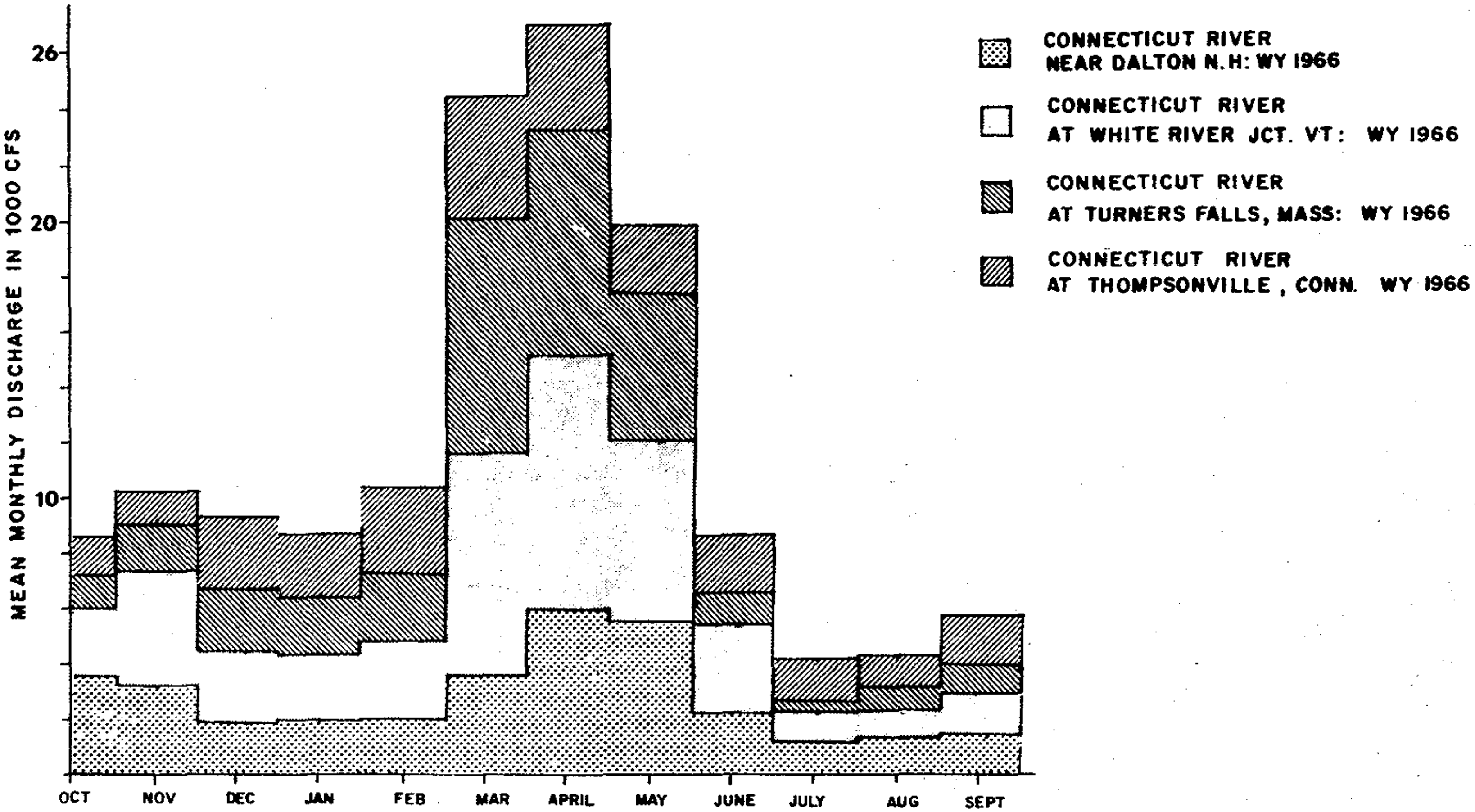
Flows in the Connecticut River Basin are affected by both natural and man-caused regulation. In the first instance, natural flows vary seasonally, with high flows generally occurring from March to May, and low flows between July and September. Monthly flows at selected basin locations are shown in Figure 15. Man-caused regulation is more typically daily and hourly in character, and generally occurs due to the operation of industrial and hydroelectric reservoirs. Flow on the main stem is regulated by 15 major impoundments, while flows on almost all tributaries are affected by impoundments. Figure 16 shows a profile of the main stem and the location of major impoundments.

Operation of the 11 hydroelectric dams on the main river is in accordance with the peak power demands of the New England Market area, and also hydrologic factors such as river flows, available pondage and economic preference of generating from one impoundment in lieu of another. Figure 17 indicates both the negligible week-end flows as well as the intermittent daily operation during week-days. This figure also indicates that recorded average daily river flows do not reflect instantaneous flow variations. It emphasizes the need for prescribed minimum instantaneous flow releases from all dams.

Water quality analyses made during the study and described in Appendix D conclude that flow augmentation can be an important tool in improving water quality. This comprehensive study measured only the dissolved oxygen parameter in its computer evaluation of flow augmentation and water quality. Besides raising oxygen levels, augmentation will also have an important effect in diluting non-degradable wastes, diluting wastes from diffused sources, in increasing river levels for fishing and recreating, in providing higher velocities which will inhibit aquatic growth in lowering stream temperatures, and in generally providing an improved flow regimen.

The need for improved flows to enhance fishing and recreation are noted in detail in Appendices G and H respectively. Flows required to meet fishery goals are described in Section V-F and G of this appendix. Stream flows required to provide minimum, marginal and optimum recreation value are presented in Appendix H, as a guide to the formulation of an operation schedule for stream regulation.

In the preparation of the Basin Plan the preceeding referenced needs and concepts were used as a basis for preparing estimates of



NOTE: Discharges shown are not adjusted for changes in contents of reservoirs.

CONNECTICUT RIVER BASIN
COMPREHENSIVE STUDY

MONTHLY FLOW VARIATIONS
CONNECTICUT RIVER

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION BOSTON, MASS.

FIGURE 15

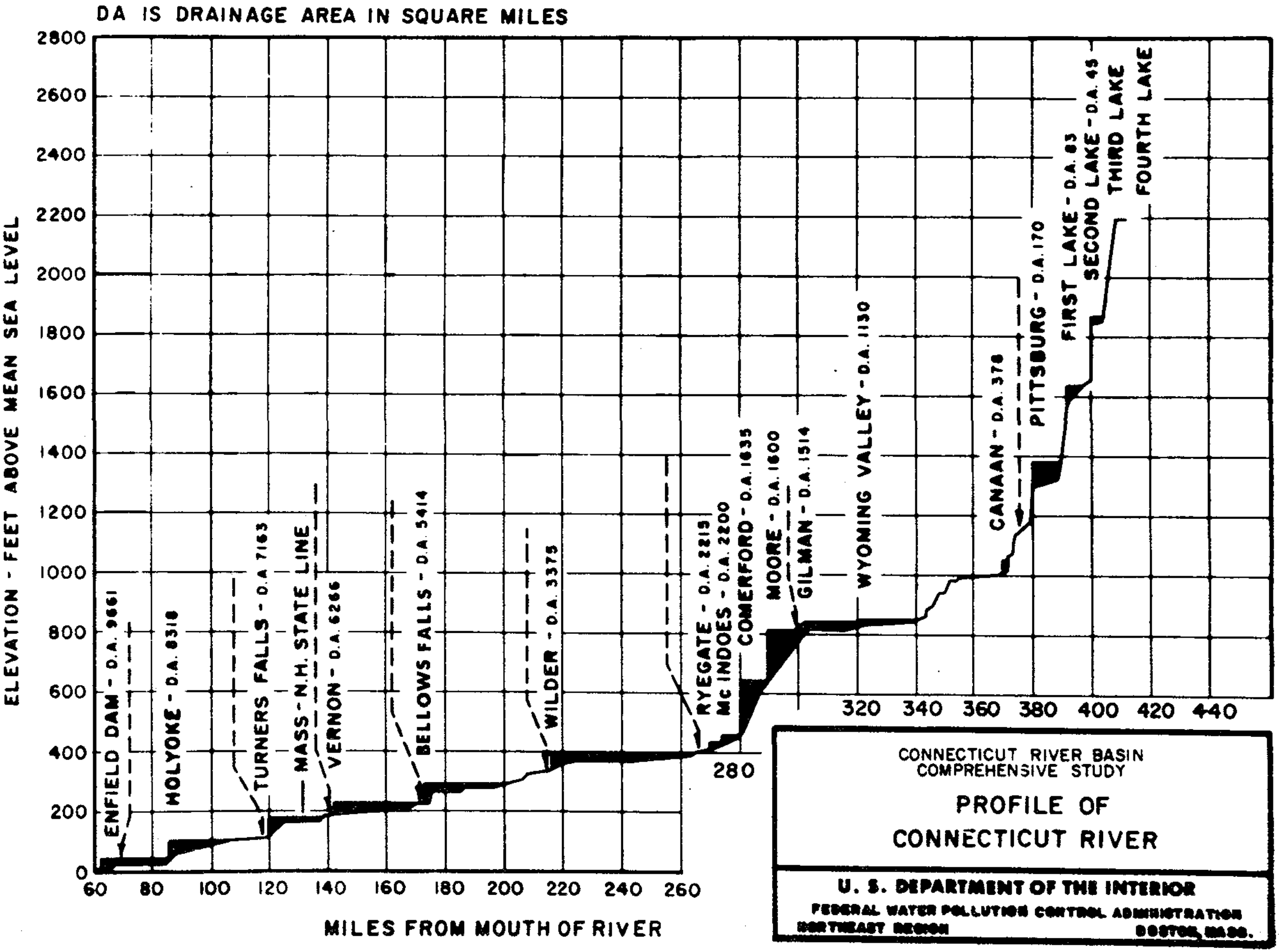
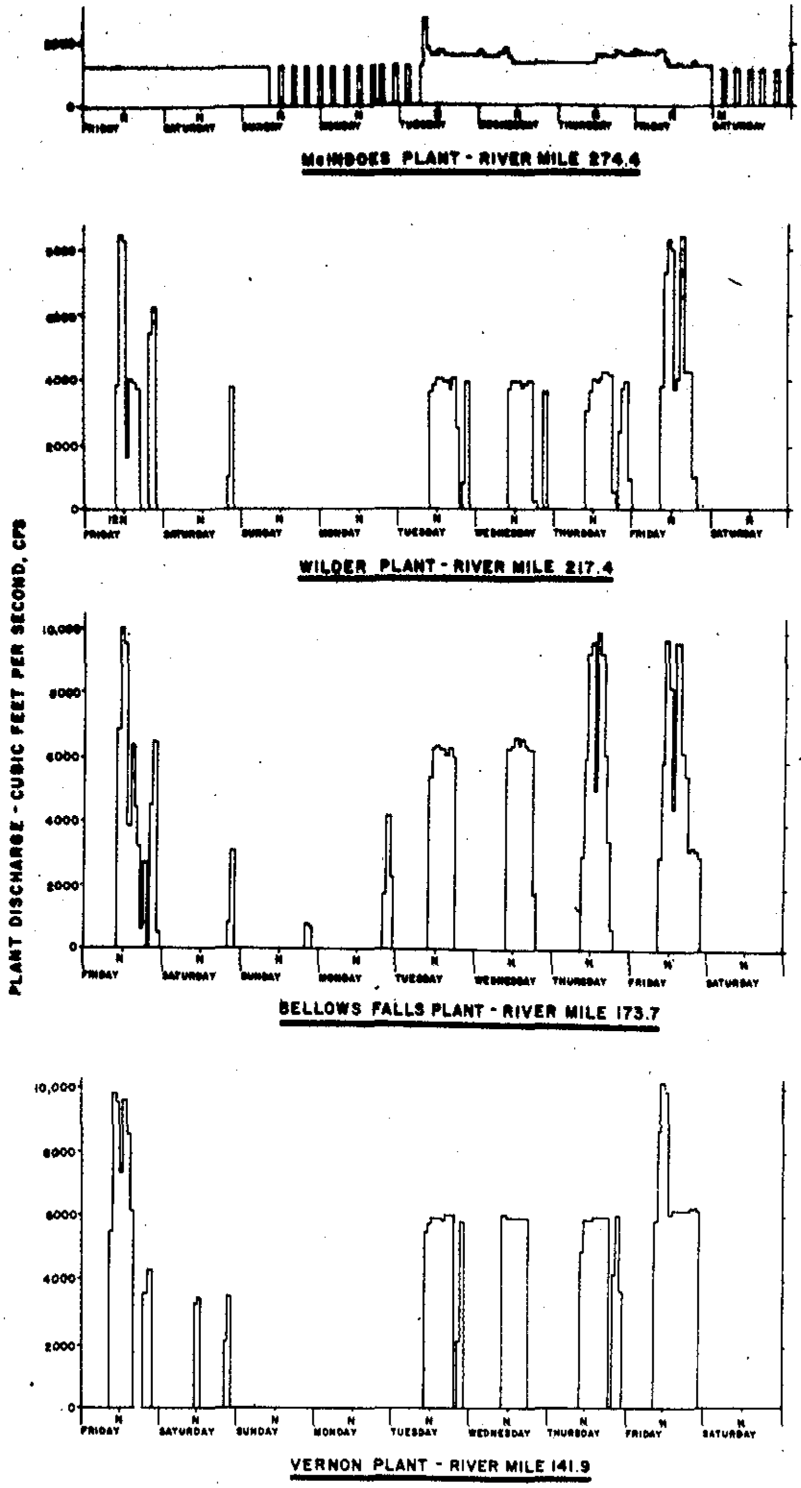


FIGURE 16

K-147



NOTE:
DISCHARGES INDICATED ARE FOR PERIOD FROM FRIDAY, SEPTEMBER 4, 1964 TO SATURDAY, SEPTEMBER 12, 1964

CONNECTICUT RIVER BASIN
COMPREHENSIVE STUDY

SELECTED HYDROELECTRIC DAM OPERATION

U. S. DEPARTMENT OF THE INTERIOR

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHEAST REGION BOSTON, MASS.

FIGURE 17

the flow augmentation required in basin streams. In certain instances, particularly on upstream reaches of tributaries, projects are needed primarily to provide flow releases for enhancement of stream fisheries. On the lower reaches of several tributaries flows are needed to improve water quality. On the main stem, flows are needed for various reasons in most reaches throughout the river. On the lower main stem, below Holyoke Dam, flows will assure adequate waste assimilation and help maintain adequate project depths for navigation. On the upper main stem, from Groveton, New Hampshire downstream to the Passumpsic River, increased flows could be an effective measure in providing the oxygenation necessary to assimilate wastes and to maintain water quality standards.

Throughout the entire main stem the higher flows will help to dilute bacteria and non-degradable wastes. They will also improve the potential for recreation throughout the river. Finally, general recommendations of the Technical Committee for Anadromous Restoration include requirements for improved flows along the river. These are specified in several phases in this report as follows:

Wilder Dam	850 cfs
Bellows Falls Dam	1,350 cfs
Vernon Dam	1,550 cfs
Turners Falls Dam	1,780 cfs

The Basin Plan attempts to meet flow needs where they can be accurately determined and also tries to provide sufficient flexibility to meet either future needs or more precise determination of present needs.

VI. ELEMENTS OF THE BASIN PLAN

A. OBJECTIVES

1. General

The following three objectives form the basis of plan formulation for the Connecticut comprehensive investigations:

- National Efficiency

- Regional Efficiency

- Environmental Quality

A fourth objective could be considered and that would be to maintain the status quo and not satisfy water resource requirements. Such a line of action, of course, would not require plan formulation; in fact, it is the base against which the benefits for any plan of action are measured.

The Coordinating Committee has attempted to formulate a plan which presents a balance of all three objectives - National Efficiency, Regional Efficiency, and Environmental Quality - a plan that provides for optimum development of the basin's resources, fosters the economic growth of the region and, at the same time, preserves and enhances the unique environment of the Connecticut River Basin.

2. National Efficiency

National Efficiency is getting the greatest return and economic benefits by investing in water resource restoration and development from the viewpoint of the whole country. Participants in this study have endeavored to produce a plan wherein the individual projects are developed to a scale which maximizes the net benefits. That is, the size of the development was increased until the cost of the last separable increment was equal to the benefits produced by that increment. In line with the guidelines expressed in Senate Document 97, economic desirability means that for each feature of the plan:

- The benefits exceed the cost.

- Each separable segment is incrementally justified.

- The scale of development provides a maximum of excess benefits over cost.

- No more economical means of accomplishing the same purpose is precluded by the project.

This means that in addition to developing a B/C ratio that is greater than unity, we want to develop plans that are as close to maximum net benefits as study time and data permit.

3. Regional Efficiency

Regional Efficiency is producing the greatest return in economic and social benefits by investing in water resource restoration and development from the viewpoint of the Connecticut River Basin. Not all of the elements in the recommended plan produce the greatest national efficiency. There are several areas of the basin which are presently in an economically depressed state when compared with the economy of the Nation, the economy of New England or the economy of other regions of the basin. The study has tried to produce projects which will produce a geographic balance of social and economic benefits. Several of the projects and recommendations of the plan are in areas that need an economic push.

4. Environmental Quality

Environmental Quality objective of framework planning is the improvement of the quality of the environment through water resource investment. This objective includes not only preservation but positive measures to restore and enhance the present environment. The goal of this objective is to insure that the effects of water resource development on the environment are carefully defined and evaluated. It is not possible to express environmental objective in terms of national income or national objectives; but there are some systematic ways in which environmental quality objective and effects can be assessed. It is important that the real importance of various effects be determined within our planning environment. For instance, it is important to appraise the fact that the problems of environmental quality will be different in one section of the basin from those in other sections. The relationship between man and his urban environment may be totally different from that between man and a more rural environment. This environmental quality objective is a new approach in water resource development especially as concerns the restoration and enhancement aspects. Within the limits of the study, time and available data, an attempt was made to determine the nature of the environment of the Connecticut River Basin, to analyze what the effect of the future population and water resource demands would be on this environment and to decide whether the needs to meet these demands were worth the change that they might bring about in the present environment.

B. GOALS

1. Water Quality

The basic goal for water quality in the Connecticut River Basin was the attainment of the joint State-Federal water quality standards which have been established by the States of Vermont, New Hampshire, Massachusetts, and Connecticut. These standards, in effect, are an initial water use plan for the basin arrived at through the political process. They provide for public health, public enjoyment, water supply needs, propagation of fish and wildlife, and economic and social development. The water quality standards include use designations for each water body; criteria for measuring the quality of the water; and an implementation schedule for the construction of treatment facilities. In general, standards require that wastes receive secondary treatment with disinfection or the industrial waste equivalent before discharge to a receiving water. Current implementation schedule calls for completion of necessary treatment facilities by about the mid-1970's. Present day technology and practicability of waste treatment require that the adjacent waters accept some portion of the treated waste generated.

A major goal in the development of the basin's water resources is to provide waters suitable for recreation, fish and wildlife, enhancement and general aesthetic attractiveness. Primarily this should be accomplished by the construction of at least secondary wastewater treatment facilities prior to provision of flow augmentation for pollution abatement.

2. Power

Studies were made to determine whether economical and favorable sources of power supply could be developed by the Federal Government in the basin. As a result it was concluded that the 1980 power needs of the basin could best be met by the on-going programs of the power companies in New England. Primary concern then was to assure that development of water resources for other purposes did not preclude opportunities for providing economical power and that the water resource requirements of power development did not adversely limit the use of water for other purposes.

3. Outdoor Recreation

In planning for recreation, in view of the unsatisfied demand, major emphasis was given to maintaining the present quality of the environment. It is not felt that the total demand for additional surface water could be met by water resource development without having an adverse effect on this quality, and for this reason the Coordinating Committee did not attempt to meet the total unsatisfied recreation demand for 1980. The Early Action Plan attempts to meet the unsatisfied demand for outdoor recreation without reducing the quality of the experience.

4. Environmental Preservation

To insure that the present quality of the environment is either maintained or enhanced, the Committee feels that measures should be taken to preserve areas of natural and historical significance within the basin in their present state. The goal of the study was that this be accomplished through joint Federal, State, and local programs and that it be done in conjunction with meeting water resource needs and maximizing multiple benefits.

5. Anadromous Restoration

As part of the enhancement of natural resources of the basin, the Committee indorses the goal of restoring historical salmon and shad runs to the river. The Committee also believes that simultaneously with the establishment of the anadromous fishery there should be a program of streambank acquisition to make this new resource available to the public.

6. Resident Fish and Wildlife

The objective of the study was to satisfy the pressures which are exerted on the fish and wildlife resources of the basin. The study tried to meet the fishing and hunting demands of the expanding population while insuring that adequate controls are imposed to protect and enhance the existing stream and lake resources. Major emphasis was placed on providing high quality water, improvement of facilities, provision of access, and supplementation of flows.

7. Water Supply

A goal of the study was to assure that all projected municipal and industrial needs for water can be met adequately. It was not felt that the study could adequately design systems for each community in the basin. However, attempts were made to assure that there were no water supply problems of a magnitude that needed to be handled with a regional solution. Where possible, water supply needs of local communities were incorporated in multiple-purpose water development projects. The study also tried to determine whether in-basin water supply demands could be met before out-of-basin diversions were permitted.

8. Navigation

Navigation goals for the Connecticut River Basin were considered in three parts. First, an assessment of the economic feasibility of improving commercial navigation from Long Island Sound to Holyoke. Second, an evaluation was made of the economic feasibility of providing recreational boating improvements from Long Island Sound through White River Junction. Finally, an assessment was made of the possibility of canoeing improvements on major tributaries.

9. Land Use, Watershed Protection, and Management

The objective for land use in the basin was to assure that optimum use could be made of the land to meet the needs of the future. The attempt was to develop a plan which could be used as a guide in future land use adjustments and one which would assure that the most suitable lands are retained for agriculture and environmental quality. Land use treatment and improved multiple use management measures were employed to reduce erosion and sediment. Acquisition was utilized as a measure to preserve and control land within National Forests proclamation boundaries.

10. Flood Control

The goal of the study was to provide the maximum degree of flood protection consistent with the established policies of economic justification, the safety and security of affected communities, and the overall well-being of the people. Emphasis was placed on protection of existing damage-prone areas and also, to the extent possible, on the elimination of further flood plain encroachment.

The Coordinating Committee endorsed the aims of the Connecticut River Valley Flood Control Commission in securing adequate runoff control in the basin and the completion of the authorized plan of flood protection. Upstream watershed protection and flood prevention project measures were considered equally with major control measures such as large reservoirs and local protection.

It was also the goal of the Committee to inform the public of the alternative measures which might be employed and to encourage individual communities to assume appropriate responsibilities such as zoning and improved building codes.

C. STUDY APPROACH

Five basic steps were performed by participants:

- Economic projections were made.
- An inventory was made of all available resources and present development.
- Needs in each resource category were determined.
- All possible potential resources were evaluated.
- A comparison was made between resource needs and available potential, and a plan was formulated.
- A report was prepared.

With the exception of the first step, development of economic projections, which was done outside of the study group, each agency used the same procedure in forming its plan. The four steps of this procedure were used repeatedly by each participant, for each water resource purpose, for each sub-basin, and then for the total basin. Then an interim report, or planning aid letter, was prepared and submitted, modifications were made in the original conclusions and the procedure was enacted again. Periodically throughout the study, participants brought their single-resource oriented views together in roundtable discussions, where further adjustments and compromises were made or new study areas were identified.

As noted previously every effort was made to solve problems or to satisfy needs by economical use of existing facilities. Lacking that possibility an attempt was made to accomplish goals by modification of present structures. Finally, when it became evident that new proposals would be required to fulfill an objective, the emphasis was placed on multiple-purpose development.

The following paragraphs present the elements of the basin plan as they were formed from this plan formulation process. Emphasis was placed on quantitatively meeting the needs and goals of the 1980 time frame. Beyond 1980, and through the year 2020, the study identified measures for meeting needs and solving problems but did not formulate a plan. Also during the plan formulation process, numerous alternative courses of action were investigated and are discussed fully in Section VIII of this Appendix.

D. ELEMENTS OF THE 1980 EARLY ACTION PLAN

1. Non-Structural Measures

a. Areas of Preservation

(1) Identification of almost 600 sites of archeological importance and over 250 sites of either natural resource or historical importance with the recommendation for concerted local, State, and Federal effort to protect these areas. (Reference Appendix O)

(2) Acquisition of 69,300 acres of land within National Forest proclamation boundaries, 4,300 acres in the White Mountain National Forest, and 65,000 acres in the Green Mountain National Forest. (Reference Appendix F)

(3) Zoning of flood plains along over 200 miles of the main stem of the Connecticut River from Saybrook, Connecticut to above White River Junction, Vermont to prevent further encroachment. (To be coordinated with (4) and (5) below.) (Reference Appendix M)

(4) Creation of a statewide scenic river program to preserve, protect, and enhance all reaches of river identified in the comprehensive report as Wild, Scenic, or Recreational. Priorities for stream management consideration by sub-basin include all or part of:

Sub-basin I	Sub-basin II
Indian Stream	Nulhegan River
Upper Ammonoosuc River	Paul Stream
Nash Stream	Moose River
Phillips Brook	Wells River
Ammonoosuc River	Waits River
	Ompompanoosuc River

Sub-basin III

Cold River
Ashuelot River

Sub-basin IV

White River
Ottauquechee River
Williams River
West River

Sub-basin V

Millers River
Tully River
Deerfield River
Sawmill River
Ware River
Swift River (Chicopee)
Westfield River
Clam River

Sub-basin VI

Scantic River
Farmington River
Sandy Brook
Hockanum River
Ketch Brook
Podunk River
Park River
Salmon River
Dickinson Creek
Fawn Brook

(Reference Appendix H and Plate K-17.)

(5) Streambank acquisition necessary to assure public access to basin fishery resources. To be coordinated with (3) and (4) above.

(6) Establishment of a three-unit National Recreation Area in the Connecticut River Basin generally as described in the recommendations of the Bureau of Outdoor Recreation's "New England Heritage" report (reference Appendix H) as follows:

(a) Federal Action:

- A three-unit National Recreation Area, 56,700 acres

- Gateway Unit, Connecticut, 23,500 acres

- Mount Holyoke Unit, Massachusetts, 12,000 acres

- Coos Scenic River Unit, New Hampshire and Vermont, 21,200 acres (1,000 in fee)

- Connecticut Valley Trail, 300 miles long

- Connecticut Valley Tourway - suggested tours on existing roads to points of historic, scenic, educational, industrial, archeologic, and geologic interest, Federal-State-local cooperative effort.

(b) State Action, complimentary to the three-unit National Recreation Area:

- Gateway Unit: Cockaponset State Forest - expand existing holdings to form a contiguous 18,300-acre State forest.

- Mount Holyoke Unit: Mount Tom State Park - expand existing Mount Tom State Reservation adjacent to Mount Holyoke Unit to form a 4,800-acre State park.

- Coos Scenic River Unit: Connecticut Lakes State Park - enlarge existing holdings to create a 14,000-acre State park at the northern end of the Coos Scenic River Unit.

- Moore-Comerford Interstate Park - joint development with private power company of lands surrounding Moore and Comerford Reservoirs to form a 15,400-acre Interstate park.

(c) Other State Action

- Connecticut: Glastonbury Meadow State Park - 4,400 acres Windsor Locks-King's Island State Park - 250 acres.

- Massachusetts: Turners Falls-Northfield Mountain State Park - 31,000 acres, joint State-private power development, utilizing existing State lands and acquisition.

- New Hampshire and Vermont: Rogers' Rangers Historic Riverway - 27,500 acres. Reference for element (6) is Appendix H.

b. Areas of Management or Reallocation of Resources

(1) Reregulation of existing impoundments to provide adequate minimum flow releases; specifically minimum releases of 0.2 cubic feet per second per square mile of drainage area at four power projects on the main stem of the Connecticut River, namely Wilder, Bellows Falls, Vernon, and Turners Falls. (Reference Appendix Q, Report of Subcommittee on Stream Regulation)

(2) Continued studies into feasibility of using water supply impoundments for increased recreation and fish and wildlife use. (References Appendix D, G, H, and R)

(3) Further water quality studies in the areas of storm and sanitary sewer separation, control or elimination of sludge deposits in reservoirs, and excessive runoff and sediment from agricultural and urban areas. (Reference Appendix Q, Report of Water Quality Subcommittee.)

(4) Land treatment measures to 204,000 acres of crop and pasture land, 823,000 acres of private non-industrial forest land, 64,000 acres of National Forest lands, and 150,000 acres of urban and other lands. Soil surveys and watershed analysis on 306,600 acres of National Forest land and fish and wildlife surveys and analysis on 30,500 acres of National Forest land. (Reference Appendix F)

(5) Acceleration of planning assistance to 180 towns in preparation of resource inventories, town soil reports, and interpretations and flood plain studies. Acceleration of soil survey programs involving 1.5 million acres. (Reference Appendix F)

(6) Improvement and expansion of the existing flood warning system.

(7) Programs to inform public of availability of flood plain insurance and flood fighting.

(8) Expansion of present basin water quality monitoring system.

(9) Establishment of a reservoir control center for regulation of reservoirs during critical hydrologic periods.

(10) Effective implementation of State programs particularly with respect to preservation of wetlands, establishment of encroachment lines and programs for environmental control.

(11) General recommendations:

- Establishment of an urban and forestry program
- Modification and expansion of the Agricultural Conservation Program
- Expansion of municipal watershed forestry assistance programs.

2. Structural Measures

a. Construction of those waste treatment facilities required to meet State water quality standards in the basin. (Reference Appendix D)

b. Expansion of the existing basin power supply system to meet those power demands which will be allocated to the Connecticut River Basin. (Reference Appendix I)

c. Construction of seven major reservoirs in which flood control is a prime purpose included is one project in the design stage, Beaver Brook on the Ashuelot River in New Hampshire. Of the remaining six reservoirs, two, Victory on the Moose River and Gaysville on the White River are in Vermont; three, Bethlehem Junction on the Ammonoosuc River, Claremont on the Sugar River and Honey Hill on the Ashuelot River, are in New Hampshire; and the remaining site, Meadow, is in Massachusetts on the Deerfield River. Pertinent data on these projects are shown on Table , also reference Plate K-2 and Appendix M.

d. Modification of three existing Corps of Engineers' flood control dams to include allied purpose such as recreation, fish and wildlife and water supply. Projects are:

- Knightville Dam on the Westfield River in Massachusetts to be raised to include a pool for recreation and storage for low flow augmentation to enhance downstream fisheries
- Barre Falls Dam on the Ware River in Massachusetts to impound seasonal storage for low flow augmentation for water quality. Possible alternative to advanced waste treatment measures.

- Union Village Dam on the Ompompanoosuc River in Vermont to provide a summer recreation pool; contingent upon the solution to an existing water quality problem on the West Branch of the river.

- Tully Dam on the Millers River in Massachusetts to include facilities to divert water supply to Quabbin and to provide water-based recreation activity. (Reference Appendix M)

e. Construction of three reservoirs on major tributaries where flood control is not a primary purpose (Reference Appendix M):

(1) Blackledge Dam and Reservoir on the Salmon River, Connecticut for recreation, fish and wildlife and low flow augmentation.

(2) Cold Brook Dam and Reservoir on Roaring Brook, Connecticut for recreation, fish and wildlife and minor flow augmentation.

(3) Gardner Dam and Reservoir on Otter River, Massachusetts for low flow augmentation, as an alternative if advanced waste treatment measures are not effective.

f. Local flood protection projects at five locations in the basin. (Reference Appendix M)

(1) Westfield, Massachusetts - 45,000 linear feet of earth dikes, about 1,500 feet of concrete floodwalls, two pumping stations, and 16,000 linear feet of channel improvement on the Little and Westfield Rivers.

(2) Lancaster, New Hampshire - small ice retention dam on the Israel River about one and one-half miles upstream of its mouth, together with 2,800 linear feet of channel improvement.

(3) Hartford, Vermont - improvement to 3,000 linear feet of the White River from the vicinity of Hartford Bridge to the mouth.

(4) St. Johnsbury, Vermont - 1,200 linear feet of protective earth dike and concrete floodwall, a railroad gate structure, and a pumping station located on the Passumpsic River.

(5) Park River, Connecticut - 12,816 linear feet of conduit junction strucutre, headwall and pumping structure along the Park River in Hartford, Connecticut.

g. Upstream watershed protection projects at 17 locations in the basin. (Reference Appendix F)

(1) Eight PL566 watershed projects currently authorized for planning are:

- West Branch, Westfield River project, Massachusetts, comprised of 95 square mile drainage area with 11 storage sites retained for flood prevention. 10,150 acre-feet of storage for recreation and fish and wildlife use is also being considered as a part of the project.

- Upper Quaboag River (Supplement) project, Massachusetts, comprised of 147.4 square miles drainage area with 5 storage sites planned for flood prevention. 3,900 acre-feet of storage for recreation, water quality and water supply is also being considered as a part of the project.

- Wells River project, Vermont, comprised of 99.7 square miles drainage area with 6 storage sites planned for flood prevention. 7,300 acre-feet of storage for recreation is also being considered as a part of the project.

- Sugar River project, New Hampshire, comprised of 275 square mile drainage area with 10 storage sites planned for flood prevention. 15,400 acre-feet of storage for recreational use is also being considered as a part of the project.

- Blow-Me-Down Brook project, New Hampshire, comprised of 28.3 square mile drainage area with 4 storage sites planned for flood prevention. 700 acre-feet of recreation is also to be considered as part of the project.

- Indian-Mascoma River project, New Hampshire, comprised of 133.6 square mile drainage area with 7 storage sites planned for flood prevention. 23,000 acre-feet of storage for recreational use is also being considered a part of the project.

- Gale River project, New Hampshire, comprised of 91 square mile drainage area with 2 storage sites planned for flood prevention. 660 acre-feet of storage for recreational use is also being considered.

- Indian Brook project, New Hampshire, comprised of 2.2 square mile drainage area with 1 storage site for flood prevention. 780 acre-feet of storage for recreational use is also being considered.

(2) Nine potential watershed projects are:

- Mill River project, Massachusetts, comprised of 59 square mile drainage area with 3 storage sites for flood prevention. Included is 3,800 acre-feet of storage for recreation and water supply.

- East Branch, North River project, Vermont, comprised of 39 square mile drainage area with 1 flood prevention site which includes 1600 acre-feet of storage for recreation and fish and wildlife use.

- North Branch, Deerfield project, Vermont, comprised of 50 square mile drainage area with 5 storage sites for flood prevention. Included is 2700 acre-feet of storage for recreation and fish and wildlife.

- Whetstone project, Vermont, comprised of 28 square mile drainage area with 5 storage sites for flood prevention. Included is 5600 acre-feet of storage for recreation and fish and wildlife.

- Ball Mountain Brook project, Vermont, comprised of 35 square mile drainage area with 2 sites for flood prevention. Included is 4000 acre-feet of storage for recreation and fish and wildlife.

- Black Brook project, Vermont, comprised of 195 square mile drainage area with 3 sites for flood prevention.

- Passumpsic-Moose Rivers project, Vermont, comprised of 374 square mile drainage area with 8 sites for flood prevention. Included is 13,300 acre-feet of storage for recreation and fish and wildlife.

- Upper Ammonoosuc River project, New Hampshire, comprised of 254 square mile drainage area with 3 sites for flood prevention. Included is 43,200 acre-feet of storage for recreation, water quality, and water supply.

- Mohawk River project, New Hampshire, comprised of 56 square mile drainage area with 2 sites for flood prevention. Included is 10,000 acre-feet of storage for recreation.

h. Completion of four resource conservation and development projects which have substantial areas within the basin. (Reference Appendix F)

(1) North Country resource, conservation, and development project in Coos, Grafton, and Carroll Counties with 1,201,700 acres in the basin.

(2) Eastern Connecticut resource, conservation, and development project with 26,000 acres in the basin along the eastern divide.

(3) Berkshire-Franklin, Massachusetts, resource, conservation, and development project with over 600,000 acres in the basin.

(4) East central Vermont resource, conservation, and development project including the White River and adjacent areas.

i. Other upstream impoundments at 118 sites not presently covered by existing Federal programs. (Reference Appendix F)

Sites would have a total storage capacity of 463,000 acre-feet of which 68,000 acre-feet would be for floodwater and sediment, 156,000 acre-feet for recreation, 111,000 acre-feet for fish and wildlife, 108,000 acre-feet for low flow augmentation, and 20,000 acre-feet for public water supply. A total of 18,200 acres of water surface area and flow augmentation benefitting 467 miles of downstream fishery would result from these sites.

j. Structural developments on National Forests lands (Reference Appendix F) to include:

(1) 555 acres of recreation facilities

(2) 310 acres of recreational impoundments

(3) 255 miles of roads and trails

(4) 37 fire control heliports

(5) 37 acres of fish and wildlife improvements

k. Navigation improvements as follows:

(1) Deepen and widen the present commercial navigation project from Saybrook Light to Hartford, Connecticut

(2) Construction of a 32-mile recreational navigation project from Hartford, Connecticut to the vicinity of the Williamansett Highway Bridge below Holyoke, Massachusetts

(3) Recreational navigation improvements on the main stem of the Connecticut River behind the Holyoke, Turners Falls, Vernon, and Bellows Falls power dams. (Reference Appendix L)

l. Construction of fish hatcheries necessary to meet requirements of the anticipated resident and anadromous fish programs.

E. POTENTIAL 2020 MEASURES

The "Long Range Plan" or "2020 Plan" presents an identification of potential means for meeting needs of the 2020 time period. These potentials would be studied in more detail and brought to the attention of local interests sometime after 1980, or as the long-range needs appear to materialize. Future studies or technological innovations may indicate needs other than those identified below which would warrant consideration.

Several of the elements in the "2020 Plan" are extensions or expansions of those found in the Early Action Plan.

1. Non-structural

a. Preservation, Conservation, and Utilization

(1) As population expands a more concerted Government and private effort will be needed to preserve sites of archeological, historical, or natural importance. (Reference Appendix O.)

(2) There should be a continuing expansion of flood plain management programs, particularly on tributaries to the Connecticut River, to prevent further encroachment on flood prone areas and reduce future damage. (Reference Appendix M.)

(3) As programs are established in regard to early action recommendations for recreation resources, and as other public and private actions develop, the basin's resources and the region's socio-economic characteristics will change. A continual program should be established to facilitate early action recommendations to monitor basin resources and socio-economic characteristics and to establish new priorities. (Reference Appendix H.)

(4) The streambank acquisition program, necessary to assure increased public access to the basin's fishery and recreational resources, will need to be expanded to other tributary areas. (Reference Appendix G.)

b. Areas Where Improved Management of Existing Resources Could Meet 2020 Needs

(1) Re-regulation - All power projects of each utility in the basin should be included in a single license. A minimum flow formula, such as the 0.20 cfs per square mile of drainage recommended

in the Early Action Plan, should be applied through appropriate procedures to all power storage and generation projects in the Connecticut River Basin, with provisions for periodic review and adjustments. (Reference Appendix Q - Report of the Stream Regulation Subcommittee.)

Under this review procedure the advisability of reallocation of existing storage to other purposes should be considered. This is particularly relevant to existing power storage reservoirs if conventional hydroelectric generation becomes outmoded or otherwise discontinued.

(2) Land Treatment and Management. - Land treatment for target year 2020 will be needed on an additional 3.6 million acres; composed of 50,000 acres of crop and pasture land; 3.4 million acres of private, non-industrial forest land; and 150,000 acres of urban and other land. (Reference Appendix F.)

(3) Land Resource Planning. - By target year 2020 soil surveys need to be completed on an additional 3 million acres. Also, an additional 188 towns in the basin will need assistance in resource planning. (Reference Appendix F.)

(4) Water Quality. - Additional and continuing assessments are needed in the areas of combined sewer and storm water overflows, eutrophication, sludge deposits, pesticides, land drainage, and erosion.

Incentives should be initiated and regulations established to encourage redesign of present plant processes, recovery processes, pre-treatment measures, and land use practices that could substantially reduce the volume of effluent and the effect,of discharged wastes. (Reference Appendix D.)

(5) Water Quality Monitoring Programs. - As the population and need for water supply increases there will be a continuing need to expand water quality monitoring programs, particularly as less desirable watersheds are used as sources of supply. Ideally, cooperative monitoring programs, including local, State, academic, and Federal agencies involved in water quality monitoring should be undertaken in order to minimize duplication of effort, to take advantage of special capabilities and to reduce cost. (Reference Appendix R.)

2. Structural

a. Water Quality

Under the pressures of future population and industrial expansion, abatement of pollution and the control of its effects must receive continuing evaluation. Facilities will have to be enlarged and controls above basic secondary treatment will likely be required in certain areas of the basin if water quality standards are to be maintained. Regional treatment facilities should also be considered.

As noted in Appendix D, the capital cost of providing basic minimum secondary water pollution control facilities sized to meet the 2020 projected waste load is estimated at $321,000,000, not including the costs of operation and maintenance, nor construction of interceptors, pumping and collection systems.

Controls above secondary treatment, through complementary actions, including advanced waste treatment and/or flow augmentation, are available and could be provided to assure desirable basin development. In the absence of other supplemental measures, the capital cost of providing advanced waste treatment for the year 2020 is estimated at slightly over $54,000,000, while operation and maintenance, computed on a 25-year life of project, would be $111,000,000.

As the total impact of the planned treatment program on water quality is felt, problem areas that may emerge will be corrected in the light of future growth patterns and technology on a case by case basis. In addition, new water quality advances will be initiated. The process will be a continuing one, requiring periodic re-evaluation of the standards; further technical investigations on such matters as combined sewers, overland drainage controls, process changes, and further treatment arrangements; and a constant awareness of the close relationship between water quality, water use, and land use.

b. Power

Assuming the same rate of growth as the New England power market, basin energy requirements may be expected to climb from 23 billion kilowatt-hours in 1980 to 200 billion kilowatt-hours in 2020. Corresponding capacity demands would increase from 5 million kilowatts in 1980 to 42 million kilowatts in 2020. On this basis, it is estimated that basin demands in 2020 will be more than the basin's available economic supply, requiring supply from sources outside the basin. If present trends continue then 2020 power needs will likely be met in large part, by nuclear fueled base load plants and pumped storage peaking plants. Fossil-steam output would decline until the turn of the century, while conventional hydroelectric generation would increase moderately.

While the general location of fossil and nuclear steam units is fairly well defined in the basin through 1990, beyond that time siting becomes very speculative. At this time, however, it seems that the large base-load plants of the future will most likely be developed on the main stem of major waterways, the estuary reaches of major streams, along the coast, or on the shores of large inland water bodies.

Appendix I lists 25 conventional hydroelectric units which have potential for future development, as well as 10 pumped storage sites which could be used to meet future peak power demands.

c. Water Supply

Future demands will necessitate the development and use of water supply resources not hitherto utilized. Because of the generous yield from the basin's streams and aquifers, no serious problems with respect to future demand are anticipated. Direct stream withdrawal, with necessary treatment, may be used in areas where groundwater or reservoir sources are not competitive or available.

In some cases, the growth of certain municipalities may be curtailed where the pattern of local water supply systems continues and the locality is in a tributary headwater reach. These problems could, however, be surmounted by adequate regional planning.

One factor which may have a bearing on future water supply demands is the interrelationship between costs of waste treatment and use of water. Industries, for example, may reduce their use of process water in order to lower the cost of waste treatment. (Reference Appendix D.)

d. Navigation

In 1968 nearly 3.7 million tons of commerce were handled in the Long Island Sound to Hartford navigation improvement. Projecting the trend of recent years indicates that by the year 2020 facilities will be needed to handle 11.5 million tons of cargo.

At present, approximately 3,500 boats make up the recreational boating fleet moored or berthed on the river below Hartford. Considerable growth is anticipated in recreational boating and provisions will be needed from both private and public sectors for handling a greatly enlarged fleet in future years.

The boating pressures above Hartford will likely accelerate particularly with the effective implementation of the pollution abatement and improved flow regulation and flow augmentation programs recommended in this report. It is anticipated that boating passage may be required at main stem dams up to and including Bellows Falls. Passage could be accomplished by marine railway or navigation locks depending on the density of traffic.

Aids to navigation would be needed to identify safe channel sections in the pools associated with the Holyoke, Turners Falls, Vernon, and Bellows Falls power dams. (Reference Appendix L.)

e. Fish Hatcheries and Ladders

By 2020, recreational use of the basin's resources for fishing could increase to over 12 million fisherman days or almost 5 times the present demand. Satisfaction could be achieved by continued:

(1) creation of new reservoir fisheries
(2) restoration of anadromous fisheries
(3) enhancement of stream fisheries
(4) abatement of pollution
(5) provision of access
(6) and establishment of low flow schedules (Reference Appendix G.)

f. Multiple Purpose Reservoirs - Flood Control and Allied Purposes

The Coordinating Committee has identified several major and a number of small upstream multiple-purpose reservoirs which could be utilized to alleviate the 2020 water resource needs. The major reservoirs are shown on Plate K-2 and include:

Site	Location
Indian Stream	Indian Stream, New Hampshire
Upper Jefferson	Israel River, New Hampshire

Site	Location
Hammond Hollow	Ashuelot River, New Hampshire
Falls River	Falls River, Massachusetts
Fort Morrison	Deerfield River, Massachusetts
Natty Pond Brook	Ware River, Massachusetts
Prince River	Ware River, Massachusetts
Lower Bisbee	Westfield River, Massachusetts
Sandy Brook	Farmington River, Massachusetts

Seven potential Public Law 566 small upstream watershed projects containing 38 structures have been identified to meet requirements for flood control and allied purposes on watersheds comprising 667,000 acres of the basin. The 7 projects which are described in Appendix F and shown on Plate K-16 would be located as follows:

Ottauquechee River, Vermont
Williams River, Vermont
Saxtons River, Vermont
West River, Vermont
South River, Massachusetts
Scantic River, Massachusetts, Connecticut
Coginchaug River, Connecticut

There are a number of small upstream water impoundment sites which do not conform to the requisites of Public Law 566. Sixty-three in this category were identified for their potential to meet future storage needs, although allocation of specific storage purposes was not made. These are also described in Appendix F and shown on Plate K-16.

g. Local Protection Projects

Appendix M states that "No need is foreseen for major structural flood control measures beyond what has been recommended in the 1980 plan". However, as population increases and urban centers become more concentrated, communities which presently exist in the flood plain may grow to a level where local protection is economically justified. Out of the many local protection sites investigated seven (7) were considered as potentials for 2020 development, while another seven may make it in future studies.

2020 LOCAL PROTECTION POTENTIALS

Groveton, New Hampshire (Connecticut River)
Lebanon, New Hampshire (Mascoma River)

2020 LOCAL PROTECTION POTENTIALS

East St. Johnsbury, Vermont (Moose River)
Ludlow, Vermont (Black River)
Bellows Falls, Vermont (Connecticut River)
Brattleboro, Vermont (Connecticut River)
Windsor, Vermont (Connecticut River)

VII BENEFITS AND COSTS

A. GENERAL EVALUATION - EARLY ACTION PLAN

The following paragraphs are an evaluation of the capability of the Early Action Plan to meet the 1980 water and related land resource needs of the Connecticut River Basin.

1. Water Quality

As noted previously, many areas of the basin have water quality problems, and the basic goal of the Coordinating Committee is to meet the water quality standards established by the basin States. Accordingly, the study concludes that all pollution sources adopt at least secondary water pollution control treatment facilities with 85 percent removal of biochemical oxygen demand as an initial step in achieving desired water quality levels. The cost of constructing such facilities is estimated at $240 million for the entire basin for the year 1980 (assuming 20 year project life). This does not include the cost of operation and maintenance nor those expenditures necessary for the construction of interceptors, pumping stations and collection systems. A breakdown of the 1980 and 2020 figures by State is shown in Table 16 on page K-72.

Assuming that secondary waste treatment facilities are adopted throughout the basin, there are still a number of areas which will not meet State classifications. Water quality classification in these critical areas will have to be attained by higher degrees of treatment, by low flow augmentation, a combination of these two methods, or by other means. A list of critical stream reaches, which will have varying degrees of water quality problems even after secondary treatment, is shown in Section V of this appendix. The following is a brief discussion of alternative methods by which water quality standards can be met in these critical regions:

a. Main Stem, Connecticut River

(1) Upper Ammonoosuc to Passumpsic Rivers - In this reach pollution emanates from the effluent of the paper and pulp processing plants of Groveton Paper Company at Groveton, New Hampshire. Several means of alleviating this situation were analyzed. The most economical solution would be provision of a low flow augmentation reservoir at Indian Stream at a cost of approximately 11 million dollars, but because of the possible environmental effects of Indian Stream and due to insistence of the State of New Hampshire, the plan includes advanced waste treatment as a solution to the Groveton problem. Other alternative solutions for solving this pollution

problem were investigated and are included in Section VIII of this appendix.

In reference to existing pollution at Moore Reservoir, low flow augmentation would have no significant value. The problem in this reservoir is caused by stratification which occurs because water having a maximum density of 4° C (39.2° F) acts as a barrier to overturning and mixing. With the abatement of pollution at Groveton, it may take many years to return Moore Reservoir to its original environment if major steps are not taken to improve its condition. Possible solutions to this situation exist in such structural measures as pumps with draft tubes, mechanical aerators or aeration through tubes lying at the bottom of the water body.

(2) Westfield River to Interstate Highway 91 in Connecticut - a second portion of the main stem of the Connecticut River which would have an oxygen deficit by the year 2020 even after secondary waste treatment, is the reach between the Westfield River and Interstate 91 in Connecticut. Improvement to this reach, which will have only a minor quality problem, can be accomplished by releases from the main stem power dams on 0.20 csm as provided in the Position Paper of the Subcommittee on Stream Regulation. (Reference Appendix Q - Report of the Subcommittee on Stream Regulation)

b. Ashuelot River, New Hampshire

The Ashuelot River has severe water quality problems from Keene down to the mouth of the river. Problems are caused by discharges from the city of Keene and industries in the town of Winchester and aggravated by extremely low summer flows. There are also waste contributions from overland runoff and unidentified small sources. Construction of the Honey Hill multiple-purpose reservoir proposal which includes storage for improving flows on the Ashuelot will eliminate most of the residual water quality problems. It may be necessary to provide advanced waste treatment beyond the year 1980.

c. Black River, Vermont

The Black River is projected to have water quality problems from Ludlow to Springfield, Vermont and then from Springfield, Vermont to the mouth of the river. The lower of the two reaches can be improved by flow augmentation from the existing Corps of Engineers reservoir at North Springfield while the problem in the Upper Reach could be solved by either advanced waste treatment, or upstream flow augmentation reservoirs.

d. Millers River, Massachusetts

On the Millers River the main source of pollution occurs on the Otter River by contributions made by the city of Gardner and industrial plants in the village of Baldwinsville. Construction of the flow augmentation reservoir at Gardner could provide flow augmentation for both the Otter River and the main stem of the Millers River and, at the same time, enhance fishing on both streams.

Another minor trouble spot exists on the Millers River from Otter River to Winchendon, Massachusetts. Storage in the amount of 1,000 acre-feet would provide the necessary flow to abate pollution within this reach. The most feasible approach would be for the Commonwealth of Massachusetts to acquire Lake Monomonac and reconstruct the condemned dam one foot higher than its present elevation. Recreational opportunities could be incorporated in this project. A two-foot fluctuation, one above and one below the recreational pool, would allow sufficient storage to meet the acceptable standards of this reach.

e. Deerfield River, Massachusetts

In the Deerfield River watershed there are three troubled reaches. One is on the North River from Colrain to the mouth and another on the Green River from Greenfield, Massachusetts to its confluence. Three proposed watershed project retarding structures, in combination with advanced treatment or diversion of the Green River effluent to the main stem of the Connecticut River, would alleviate the water quality problem.

The third stretch of pollution is on the main stem of the Deerfield River from Charlemont to the mouth. Either advanced waste treatment or upstream watershed project impoundments above Charlemont would assimilate the discharge waste.

f. Chicopee River, Massachusetts

As a consequence of inadequate sewage treatment measures compounded with insufficient basin flows to dissipate waste discharge, a serious water quality problem exists on this river as well as on two of its major tributaries, the Quaboag and Ware Rivers.

On the Quaboag from Spencer to Palmer the water quality will be enhanced to meet acceptable standards with the implementation of low flow augmentation storage in the proposed Upper Quaboag watershed project.

On the Ware River two possibilities were presented. One was seasonal storage in the existing Corps of Engineers flood control dam at Barre Falls and the other was advanced waste treatment with the latter being preferred by the Commonwealth of Massachusetts at this time.

As a result of additional flow releases from the Public Law 566 modification on the Quaboag River, the Chicopee River will be improved somewhat but will still need treatment beyond secondary.

g. Westfield River, Massachusetts

Pollution occurs in two areas in the Westfield River watershed. One stretch is located in the lower reach of the Little River, a tributary of the Westfield River. Here discharge wastes from the Stevens Paper Company contributes to the degradation of the river. Along the Westfield River above Westfield, Massachusetts, a minor pollution problem originating from the Strathmore Paper Company also exists and the projected waste loadings indicate this source will become of major importance within a few years. Various watershed project structures and Corps of Engineers impoundments for low flow augmentation for assimilating the discharge waste were investigated. Other than minor low flow releases from the Knightville Reservoir modification advanced waste treatment facilities appear to be the most economical solution to pollution abatement in this watershed.

h. Connecticut

In the State of Connecticut two watershed areas are in need of low flow augmentation for improving water quality. These reaches are located on the Hockanum and the Farmington Rivers with a reach on the Pequabuck River which is a tributary of the latter. According to the State of Connecticut pollutant contributors discharging wastes into reaches of stream or river that does not meet acceptable State standards will be coerced to implement whatever treatment required to conform to water quality standards.

In this study various large and small reservoir sites were investigated for low flow augmentation for water quality. Due to either physical watershed constraints or economic justifiability none of these projects were recommended for early implementation. The approach as dictated by the State of Connecticut appears to be the best avenue of conciliation.

2. Power

The comprehensive study concluded that the region's future power requirements would be met more economically through a combination of large thermal or nuclear base load electric plants together with reversible pumped storage projects as peaking installations. For the 1980 time frame the largest block of power supply will come principally from the "Yankee" nuclear plants located at Vernon, Vermont and at Haddam Neck, Connecticut. Both of these installations have the capability of expanding their power output. While the latter can be doubled to 1,200 megawatts, the former can triple its generating capacity to 1,800 megawatts.

Continuing in the same time frame an increase in conventional hydroelectric output by installation of a power plant at Enfield Rapids together with the phasing in of two new peaking plants, at Northfield Mountain and at Bear Swamp, is contemplated. An application for a license is on file with the Federal Power Commission for a 90-megawatt Enfield Rapids conventional hydroelectric plant on the Connecticut River; while a license has already been granted by the FPC for construction of the 600-megawatt Bear Swamp pumped storage project on the Deerfield River in Massachusetts. The 1,000-megawatt Northfield plant is presently under construction and will be completed in the near future.

Beyond 1980 the power industry will be faced with a difficult task. Electrical power needs in New England for the year 2020 are projected to be more than 11 times their 1967 capability. Unless new technological advances occur to assume control of environmental ramifications, the advance of new and larger fossil-fueled and nuclear units will require siting in the estuaries or along the coast to take advantage of the larger volumes of available cooling waters and to avoid expensive cooling towers.

In view of these power demands, two conventional hydroelectric projects which were economically marginal at this time were retained as potentials to meet these long-term future power needs. Potential sites for pumped storage developments in the Connecticut River Basin are in abundance. A review of the most economically attractive ones show a potential of 9,900 megawatts available from ten sites in the basin.

3. Outdoor Recreation

Results of the comprehensive study indicate that future recreation participation will require large amounts of recreational land and water. Even after existing water bodies (not including water supply reservoirs) are further developed, some 71,000 acres of additional water surface as well as 179,000 additional acres of land will be required to accommodate this projected recreation participation under the present standards of use. These totals are spread among the four States as follows:

Additional Recreation Lands and Water in Acres

	Land	Water
New Hampshire	42,000	12,500
Vermont	37,000	12,570
Massachusetts	55,950	24,610
Connecticut	44,150	22,140
Total	179,000	71,820

The above water surface estimates do not take into account the possibility of using existing water supply reservoirs, which would reduce Massachusetts estimates to 11,450 and Connecticut estimates to 20,840 acres.

A comparison of projected 1980 water surface estimates with potential supply in the Early Action Plan is shown on Table 35 on a State-by-State basis.

Table 35 indicates that the reservoir portion of the basin plan falls far short of meeting the projected estimates for new water bodies. However, use of existing water supply reservoirs would reduce the unmet need in Massachusetts to 5,035 and the unmet need in Connecticut to 14,255 acres.

The Hartford to Holyoke recreational boating project together with the improved river access of the National Recreation Area Gateway Unit would add another estimated 5,500 acres and reduce the unmet need in the State of Connecticut to approximately 8,755 acres.

TABLE 35

WATER SURFACE AREA IN ACRES

	N.H.	Vt.	Mass.	Conn.
Planning Aid Estimates or Water Surface Needs	12,500	12,570	24,610	22,140
Proposed Corps Impoundments	2,920	3,720	930	1,965
Proposed Watershed Project Impoundments	4,180	1,630	1,075	--
Other Proposed Upstream Impoundments	2,040	4,270	4,410	4,620
Total 1980 Impoundments	9,140	9,620	6,415	6,585
Remaining Water Surface Needs	3,360	2,950	18,195	15,555

Compared to water surface estimates, the 1980 estimate for an additional 179,000 acres of land can be more completely fulfilled. The plan contains the following recommended acquisitions for land:

National Forests acquisition	69,000 acres
National Recreation Area	
- Federal	17,000
- State	42,000
Corps of Engineers impoundments	17,000
Upstream Watershed Impoundments and other upstream sites	25,000
Total	170,000 acres

This total of 170,000 acres which will be made available to the public by implementation of the basin plan does not include land area which will be included in the recommendation for streambank access for resident and anadromous fisheries; or land within the wild and scenic stream program; or land made available at State and local levels through such programs as flood plain zoning.

4. Environmental Preservation

Implementation of broad recommendations made concerning the Basin's significant archeological, historical and natural resources will help to preserve these features for future generations. It will also encourage an awareness of aesthetic and environmental considerations in all future water resource planning.

Acquisition of 69,300 acres of land within proclamation boundaries will preserve the natural integrity of the Green and White Mountain National Forests.

Recommendations for statewide scenic river programs will protect and enhance the character of basin streams, and guard against unwise exploitation. The Basin Plan identifies 28 tributaries, or portions thereof, which should have high priority for stream preservation or management.

Provisions for stream augmentation, fish passage facilities, hatcheries and improved water quality will aid in preservation and restoration of fishery resources.

Programs for better land and water controls, such as flood plain zoning and management and streambank acquisition will prevent adverse development and utilization of basin streams.

5. Fish and Wildlife

The impact of the Early Action Plan on the 1980 fish and wildlife needs of the Connecticut River Basin is discussed in detail in Appendix G. The plan will enhance basin fish and wildlife through conservation and development of existing resources, pollution abatement, improvement of access, and creation and development of reservoir fisheries.

Acquisition of 69,000 acres of national forests will help assure that public hunting and fishing opportunities will be available in the basin in the future.

Continuation of State and Federal programs to expand recreation facilities will undoubtedly benefit fishing and hunting provided specific provisions for fishing and hunting are assured on lands acquired for general recreation.

Zoning of areas either through flood plain zoning or through the State programs for landscape river areas will have a beneficial effect on fish and wildlife resources. Limitation of urban and industrial development on flood plains will leave accessible areas near urban centers. Public hunting and fishing in these areas should be encouraged where possible.

As a result of pollution abatement recommendation fisheries resources will be able to supply an additional 1 million days of fisherman use per year. Provision of flow augmentation in many reaches of tributaries will open "new" fisheries. This flow augmentation will result in a gain of over 140,000 fisherman days for resident fishing. A significant number of fishing days will also result from improvement to the anadromous fishery.

The Early Action Plan includes improved public access through the National Recreation Area Plan, an expansion of existing State recreation facilities, improvement of access to existing water bodies through the Wild and Scenic River program, the anadromous fisheries restoration program, and the resident fisheries component of the plan. Access to the river for fishing will also be provided by the recreational navigation improvements recommended in the Early Action Plan for the reach of river between Hartford and Holyoke.

All of these access improvement programs have the potential for enhancing fishing and hunting. It is important, however, that these programs specify provisions for fishing and hunting so that these accesses are not omitted.

Programs of streambank acquisition in connection with the anadromous program, the scenic river program, the National Recreation Area program, and flood plain zoning will also provide significant access.

The impact of the navigation projects upon fish and wildlife resources will depend upon the nature and depth of the areas to be dredged, as well as the selection of spoil areas. During latter design stages navigation projects should consider maximizing their beneficial impact on fish and wildlife.

Construction of fish hatcheries to provide for restoration and maintenance of the anadromous runs is included in the Early Action Plan. These hatcheries are necessary so that the program can be achieved initially. Two reservoirs in the basin plan - Blackledge on the Salmon River in Connecticut and Honey Hill on the Ashuelot River in New Hampshire include provisions for supplying water to salmon hatcheries. It should also be noted that similar provisions would be possible at several other major multiple-purpose reservoirs such as Bethlehem Junction on the Ammonoosuc River in New Hampshire and Gaysville on the White River in Vermont.

The plan also includes recommendations for fish passage facilities at 5 main stem dams, Wilder, Bellows Falls, Vernon, Turners Falls and Holyoke. The recommendations of the Subcommittee on Stream Regulation which are included in that Subcommittee's Position Paper state that the aforementioned main stem dams maintain minimum instantaneous flow releases to enhance anadromous fish runs.

The major method for satisfying fishing needs in the basin plan is through the construction of 196 upstream impoundments, 10 major multiple-purpose impoundments, and modification to 3 existing flood control dams. Construction of all the reservoirs in the plan will provide over 16,000 acres of water suitable for cold water fish species, 6,000 acres suitable for warm water fish species, about 13,000 acres suitable for a combination of cold water and warm water fish species for a grand total of 35,000 acres of water surface. Many of the sites in the plan will provide flow augmentation to basin streams, as well as surface acres of pool fisheries. Table 36 shows the impact of the 1980 basin plan upon fish and wildlife needs. Table 37 shows the impact of the 1980 basin plan upon requirements for surface area and stream miles.

6. Water Supply

Measures identified in the Early Action Plan would have a pronounced effect on water supply in the basin. Groundwater sources, noted in Appendix E, will meet the needs of many of the communities in the basin; however, the major portion of the need will continue to be met by surface water sources. Many of the reservoirs recommended in the Early Action Plan could provide water supply if needed, to local communities. The study indicated that in most instances basin communities have the capability to meet anticipated demands without creation of regional water supply systems; however, a number of the Early Action proposals include provisions for water supply. A summary of significant water supply provisions in the 1980 plan follows.

Inclusion of 3,000 acre-feet of storage in Beaver Brook Reservoir would meet additional 1980 needs of the City of Keene, New Hampshire.

Inclusion of 6,700 acre-feet of storage in Honey Hill Reservoir would provide water supply for the industrial community near Winchester, New Hampshire, and also provide a constant guaranteed 10 MGD of surface water to a possible salmon hatchery on the Ashuelot. Similarly, 10 MGD could be furnished to a possible salmon hatchery on the Salmon River, Connecticut, by the proposed Blackledge Reservoir.

Out-of-basin needs of the Metropolitan District Commission of Boston could be met, at least for the near future, by the 70 MGD average annual flood skimming diversion from Northfield Mountain to the Quabbin system. Also, a portion of the projected 1980 needs of this system could be met by a similar flood skimming and diversion from the existing Corps of Engineers reservoir at Tully.

TABLE 36

Impact of 1980 Comprehensive Plan upon fish and wildlife needs in man-days.

CRB		Stream Fishing Cold-water	Stream Fishing Warm-water	Reservoir Fishing Cold-water	Reservoir Fishing Warm-water	Waterfowl Hunting Provided
I	New Hampshire					
	1980 Need	0	0	0	0	0
	Satisfied by Basin Plan	-5,650	0	0	0	0
II	Vermont					
	1980 Need	0	0	0	0	0
	Satisfied by Basin Plan	1,450	0	0	0	200
III	New Hampshire					
	1980 Need	85,100	0	33,200	0	0
	Satisfied by Basin Plan	21,600	0	33,250	0	2,050
IV	Vermont					
	1980 Need	34,900	0	71,600	14,800	0
	Satisfied by Basin Plan	23,100	0	71,650	14,850	0
V	Massachusetts					
	1980 Needs	112,800	0	313,100	51,500	0
	Satisfied by Basin Plan	62,000	0	325,300 1/	51,600	3,150
VI	Connecticut					
	1980 Need	240,100	0	378,000	238,300	0
	Satisfied by Basin Plan	40,500	0	427,050 1/	238,150	3,150

1/ 12,200 fisherman-days in CRB V and 49,050 fisherman-days in CRB VI added to assist in meeting cold-water stream fishing needs.

TABLE 37

Impact of 1980 Basin Plan upon surface acres and stream miles available per individual.

CRB	Ac. of Lakes Current	Ac. of Lakes 1980	% Increase	Mi. of Streams Current	Mi. of Streams 1980	% Decrease	Mi. of Stream Benefited	% of Current Mi. of Stream	1980 Per Capita Acres of Lakes	1980 Per Capita Acres of Streams	2020 Per Capita Acres of Lakes	2020 Per Capita Acres of Streams
I	14,509	17,666	22	796	776	3	0	0	.535	.024	.453	.019
II	10,285	16,104	56	668	644	4	0	0	.424	.017	.322	.012
III	15,633	21,875	40	568	546	4	92	16	.233	.005	.176	.004
IV	7,077	10,875	54	954	930	3	135	14	.125	.011	.089	.008
V	32,871	40,865	24	1,059	1,026	3	393	37	.053	.001	.036	.0009
VI	7,181	15,303	113	495	478	3	203	41	.016	.0006	.009	.0003
Total	87,556	122,688	40	4,540	4,400	3	823	18	.061	.0022	.039	.0014

Many of the needed upstream watershed projects contain water supply potential. Within the 8 projects currently being planned, the Upper Quaboag watershed project contains water supply provisions for the town of Lester. Within the 9 potential watershed projects, the Upper Ammonoosuc project contains water supply provisions for the town of Northumberland, New Hampshire.

Of the 118 recommended upstream reservoir sites, there are 9 with a total of 19,000 acre-feet of water supply storage. All 9 sites are located in the State of Connecticut and are described in Appendix F.

The improved stream flows which will result from implementation of the basin plan will increase stream capability to meet process and cooling-water demands, particularly during the warmer months when flows are normally low. The recommendations for 0.2 csm minimum instantaneous releases by main stem power dams will also have a beneficial impact on meeting industrial and power water supply requirements. This is in addition to providing a supply of river water to enhance the stream fishery.

Finally, the general improvement of water quality and streamflow management will make possible the future use of major tributaries as a direct source of community water supply. Expanded water quality monitoring will assist in this respect.

7. Navigation

Implementation of the Early Action Plan will improve commercial navigation between Long Island Sound and Hartford, Connecticut. Channel deepening and widening, with a corresponding easing of bends, would provide transportation savings to some 5,000,000 tons of commerce anticipated by the year 1980, and 11,500,000 tons projected for 2020. In addition, channel widening would reduce the threat of all barge collisions, which could result in oil spills that would damage fish and wildlife areas.

The rapidly expanding demand for recreational boating would be partially met by the 33-mile Hartford to Holyoke recreational navigation improvement. It would provide improved conditions to over 10,000 boats which annually are launched in this reach of the river. Also it would accommodate 4,000 more boats in the future than could have been accommodated without this improvement.

The impact of new water bodies in meeting boating needs is described in paragraph 3 of this section. Also, to some extent, canoeing on tributaries will be enhanced by improved stream flows through reservoir construction as well as through re-regulation of existing reservoirs.

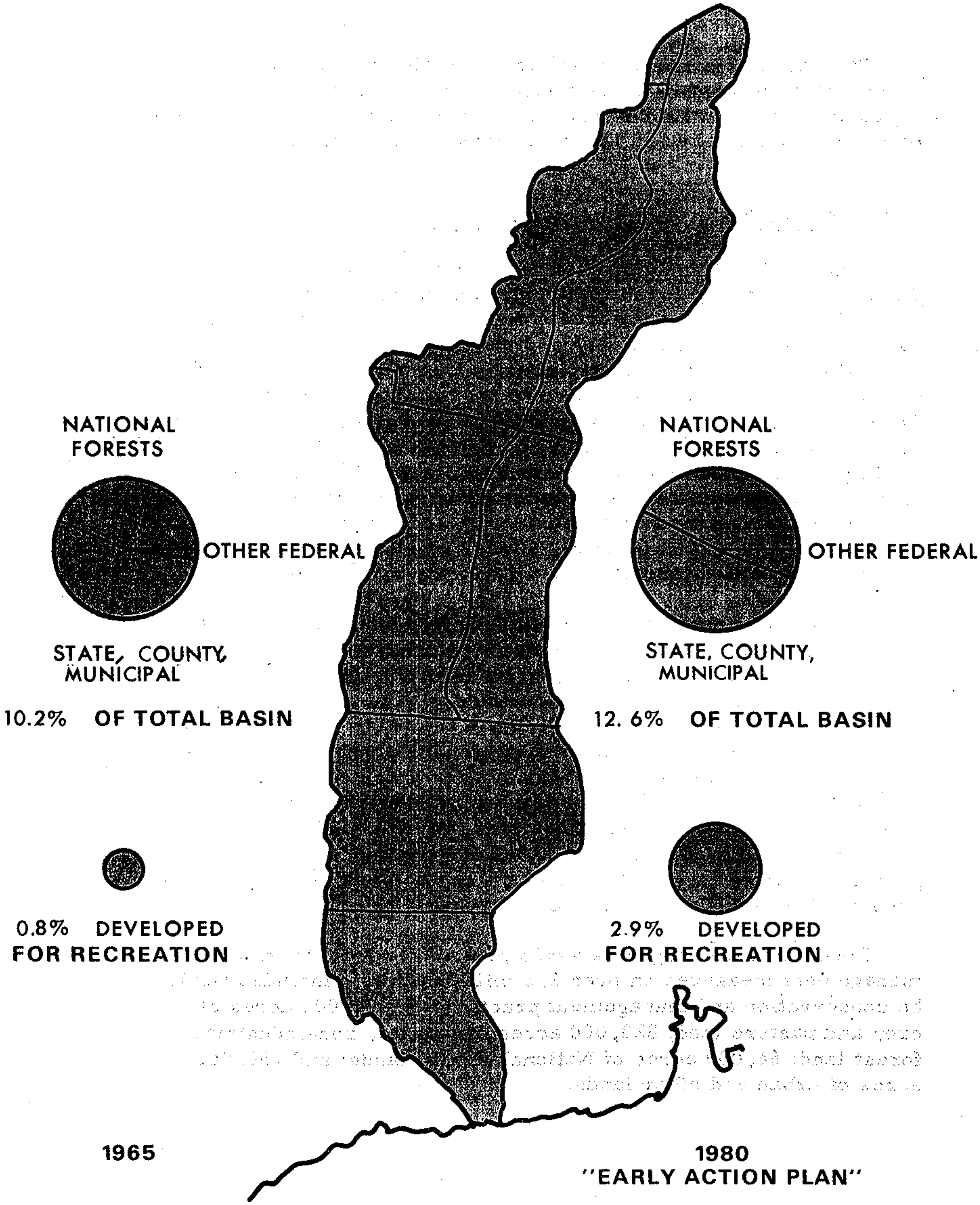
8. Land Use, Treatment, and Management

Many of the elements in the Early Action Plan will have a beneficial impact on land use, treatment, and management. Programs to acquire stream bank for access will provide open space buffer zones between developed areas and the limited water resources of the basin. Zoning of flood plains would have a similar effect by providing land for parks, open space and agriculture. Reduction of flood risk and improvement of water quality will enhance land values. These programs for acquisition and zoning of land will tend to offset the impact of the constantly diminishing areas of land devoted to agriculture. Over half of the land now being kept in an open category by reason of its use for crops or pasture is projected to shift to other uses by 1980. By 2020, studies indicate that less than 15% of current crop and pasture land will remain in its present use.

Resource, Conservation and Development projects will assist in planning for the wise use of resources through such measures as public recreational facilities, private income producing recreational enterprises, and rural industries.

Acquisition of 69,300 acres of National Forest Land and improvement of hydrologic conditions and reduction of erosion and sediment will increase the capability of our National Forests to meet other resource needs. Examples are opportunity for recreation, reduction in storm runoff, reduced erosion and sediment production, increased timber production, better access, enhanced scenic values and preservation of natural beauty.

Recommended programs would provide land treatment and management measures on over 1.2 million acres. Included would be conservation and management practices on 204,000 acres of crop and pasture land; 823,000 acres of private, non-industrial forest land; 64,000 acres of National Forest lands; and 150,000 acres of urban and other lands.



LAND AVAILABLE FOR PUBLIC RECREATION

FIGURE 18

Future population increases are expected to almost double the basin population density by the year 2020. Increased pressure will be placed on outdoor recreation resources which are developed sufficiently to be available for public use. Figure 18 indicates that in 1965 approximately 10.2% of the land in the basin is publicly owned; however, less than 1% was developed for recreational purposes. Implementation of the Early Action Plan will increase publicly available land to 12.6%, but more important it will increase the amount of land available for more intensive recreation activity such as camping and picnicking to almost 3%.

9. Flow Augmentation

The Early Action Plan provides for improved stream flow on the main stem as well as the tributaries. Recommendations of the Stream Regulation Subcommittee would increase minimum instantaneous flows by main stem power dams to at least 0.20 csm. Also, recommendations of the same Subcommittee provide that any additional flows released by upstream reservoirs also be passed by the main stem power dams. The effect of this resolution would be to increase flows for such purposes as the anadromous fishery program, recreational boating, water quality dilution, and aesthetics in general.

The Early Action Plan would add significant flows on many of the tributaries primarily to improve resident fishing and stream quality. Recommended flows for fishery enhancement are shown in detail in Appendix G - Fish and Wildlife Resources. Appendix D - Water Supply and Water Quality describes minimum flows needed to maintain adequate dissolved oxygen levels throughout the basin. Appendix F - Water and Related Land Resources Management and Use and Appendix M - Flood Control describe the capability of recommended new reservoirs, to provide flow augmentation. More definitive flow releases will be specified after elements of the plan enter design stages.

10. Flood Control

The Early Action Plan for alleviating widespread flood damages in the Connecticut River Basin is comprised of the following four interdependent parts:

(1) Seven flood control reservoirs plus 17 upstream watershed projects